CUGLE'S PRACTICAL NAVIGATION

CHARLES H. CUGLE

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CUGLE'S
PRACTICAL NAVIGATION

BY

CHARLES H. CUGLE

Author of:

SIMPLE RULES AND PROBLEMS IN NAVIGATION,
PRACTICAL ADVANCED NAVIGATION,
CUGLE'S TWO-MINUTE AZIMUTHS

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New and enlarged Edition with complete listing of navigation definitions and accessories, including the latest methods of navigation, and questions and answers used in steel hull construction and definitions used in ship stability. An addenda has been included in back of book which covers the latest method of using the Greenwich Hour Angle. Also the methods of Identification of Stars, and Distance off a fixed point or light.

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NEW YORK
E. P. DUTTON & CO., INC.

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First Printing . . . . *Nov., 1924*
Second Printing . . . *Jan., 1926*
Third Printing . . . *Aug., 1926*
Fourth Printing . . . *Nov., 1927*
Fifth Printing . . . . *April, 1929*
Sixth Printing
New and
Enlarged Edition . *July, 1930*
Seventh Printing . . . *Sept., 1932*
New, Revised Edition . *Feb., 1936*
New, Revised Edition . *Sept., 1938*
New Printing . . . . *Jan., 1941*

Printed in the United States of America

PREFACE TO NEW AND REVISED EDITION

THE purpose of this book is to lay before the student all the rules and problems in navigation used in everyday work at sea, with short definitions of the theory of navigation and other useful information that the young officer should know.

On account of the changes in the Steamboat Inspection examinations adopted lately, there has been embodied a chapter in three parts entitled "Deck Officer's Information." Part I covers general information, such as "Navigation Definitions," "Ship's Business," "Compass Adjustment," "Stowage of Cargo," and other useful information. Part II covers extracts from the Laws and Regulations of the Steamboat Inspection Service, and Extracts from the Navigation Laws of the United States. Part III Definitions used in Hull Construction and Ship Stability.

The International and Inland Rules of the Road are printed in their entirety, and the author believes that a close study of these rules in their legal form is the best method to adopt, and consequently no questions and answers regarding rules of road have been embodied in the chapter on "Deck Officer's Information."

In making up the rules for working the problems, the author may have repeated himself several times, but it has been his experience in teaching that this is essential in making the student understand.

All of the various problems are worked out in full, with no attempt to save figures or cut down the working in any way. It is recommended to the beginner that he name everything as he goes along in his problems, since it will help to memorize.

In this volume the author's previous works, "Simple Rules and Problems in Navigation" and "Practical Advanced Navigation," have been consolidated under one cover.

There are also printed Extracts from the American Nautical Almanac for 1936, which cover all of the problems in the book, and as the methods used in printing the Almanacs are similar in each succeeding year, the student can be assured that by mastering the problems for this year, he will have no difficulty in working problems for any succeeding year.

The author feels that all of the necessary problems in navigation have been taken care of in this volume, and that it is the most easily understood one ever published.

There are many excellent books on the theory of navigation, but very few that the ordinary man can understand, and this book has been published with theory eliminated entirely.

The books used in working the problems are "Bowditch American Practical Navigator"; "American Nautical Almanac for 1936"; "Cugle's Two Minute Azimuth Tables"; "Azimuths of Celestial Bodies H.O. 120"; "Noon Interval Tables H.O. 202"; "Marcq St. Hilaire Methods H.O. 208 and H.O. 211"; For the general information the books quoted are "Bowditch Practical Navigator"; "General Rules and Regulations of the Steamboat Inspection Service"; and "Navigation Laws of the United States."

It is hoped that this book will be a help to the student, as the author has tried to make it in as plain language as possible.

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Crestmont Park,
METAIRIE, LOUISIANA.

CHARLES H. CUGLE.

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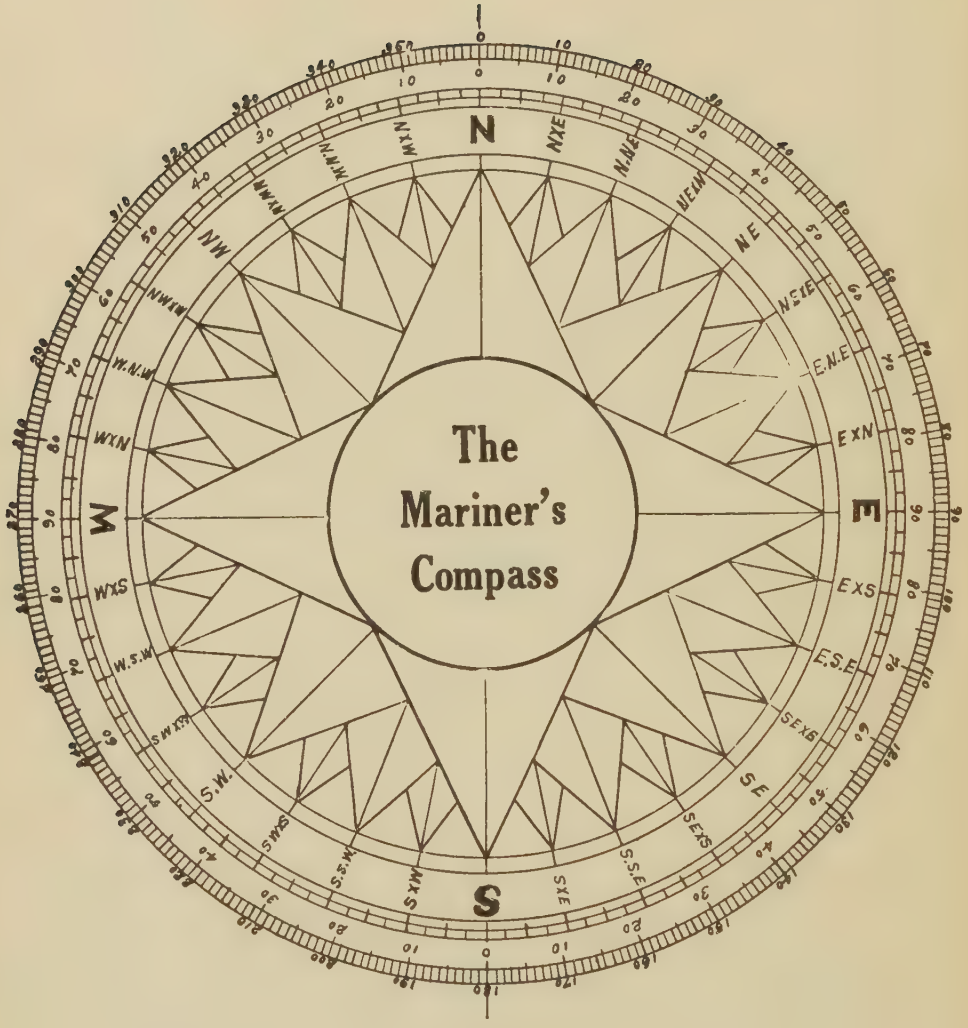
The
Mariner's
Compass
N
NXE
N.N.E
N.E.N
NE
N.E.E
E.N.E
E.N
E
E.S.E
S.E.E
S.E
S.E.S
S.S.E
S.S.W
S.W
W.S.W
W.N.W
W

TABLE FOR CONVERTING POINTS OF COMPASS INTO DEGREES.

As the Ship's Course is usually expressed in degrees, the following table will be found useful for reference.

NORTH TO EAST	NORTH TO WEST	SOUTH TO EAST	SOUTH TO WEST	POINTS	D.	M.	S.
North	North	South	South	0	0°	0	0
N ¼ E	N ¼ W	S ¼ E	S ¼ W	¼	2°	48′	45″
N ½ E	N ½ W	S ½ E	S ½ W	½	5°	37′	30″
N ¾ E	N ¾ W	S ¾ E	S ¾ W	¾	8°	26′	15″
N by E	N by W	S by E	S by W	1	11°	15′	00″
N by E ¼ E	N by W ¼ W	S by E ¼ E	S by W ¼ W	1¼	14°	3′	45″
N by E ½ E	N by W ½ W	S by E ½ E	S by W ½ W	1½	16°	52′	30″
N by E ¾ E	N by W ¾ W	S by E ¾ E	S by W ¾ W	1¾	19°	41′	15″
N N E	N N W	S S E	S S W	2	22°	30′	00″
N N E ¼ E	N N W ¼ W	S S E ¼ E	S S W ¼ W	2¼	25°	18′	45″
N N E ½ E	N N W ½ W	S S E ½ E	S S W ½ W	2½	28°	7′	30″
N N E ¾ E	N N W ¾ W	S S E ¾ E	S S W ¾ W	2¾	30°	56′	15″
N E by N	N W by N	S E by S	S W by S	3	33°	45′	00″
N E ¾ N	N W ¾ N	S E ¾ S	S W ¾ S	3¼	36°	33′	45″
N E ½ N	N W ½ N	S E ½ S	S W ½ S	3½	39°	22′	30″
N E ¼ N	N W ¼ N	S E ¼ S	S W ¼ S	3¾	42°	11′	15″
N E	NW	SE	SW	4	45°	00′	00″
N E ¼ E	N W ¼ W	S E ¼ E	S W ¼ W	4¼	47°	48′	45″
N E ½ E	N W ½ W	S E ½ E	S W ½ W	4½	50°	37′	30″
N E ¾ E	N W ¾ W	S E ¾ E	S W ¾ W	4¾	53°	26′	15″
N E by E	N W by W	S E by E	S W by W	5	56°	15′	00″
N E by E ¼ E	N W by W ¼ W	S E by E ¼ E	S W by W ¼ W	5¼	59°	3′	45″
N E by E ½ E	N W by W ½ W	S E by E ½ E	S W by W ½ W	5½	61°	52′	30″
N E by E ¾ E	N W by W ¾ W	S E by E ¾ E	S W by W ¾ W	5¾	64°	41′	15″
E N E	W N W	E S E	W S W	6	67°	30′	00″
E N E ¼ E	W N W ¼ W	E S E ¼ E	W S W ¼ W	6¼	70°	18′	45″
E N E ½ E	W N W ½ W	E S E ½ E	W S W ½ W	6½	73°	7′	30″
E N E ¾ E	W N W ¾ W	E S E ¾ E	W S W ¾ W	6¾	75°	56′	15″
E by N	W by N	E by S	W by S	7	78°	45′	00″
E ¾ N	W ¾ N	E ¾ S	W ¾ S	7¼	81°	33′	45″
E ½ N	W ½ N	E ½ S	W ½ S	7½	84°	22′	30″
E ¼ N	W ¼ N	E ¼ S	W ¼ S	7¾	87°	11′	15″
East	West	East	West	8	90°	00′	00″

ACKNOWLEDGMENT

THE Author wishes to extend his thanks for assistance to Captain John T. Sullivan, formerly master S. S. "West Kasson," U.S. Shipping Board.

CUGLE'S PRACTICAL NAVIGATION

CHAPTER I

THE INTERNATIONAL AND INLAND RULES OF THE ROAD

INTERNATIONAL RULES

I.—ENACTING CLAUSE, SCOPE, AND PENALTY

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following regulations for preventing collisions at sea shall be followed by all public and private vessels of the United States upon the high seas and in all waters connected therewith, navigable by seagoing vessels.

ART. 30. Nothing in these rules shall interfere with the operation of a special rule, duly made by local authority, relative to the navigation of any harbor, river, or inland waters.

PRELIMINARY DEFINITIONS

In the following rules every steam vessel which is under sail and not under steam is to be considered a sailing vessel, and every vessel under steam, whether under sail or not, is to be considered a steam vessel.

The words "steam vessel" shall include any vessel propelled by machinery.

A vessel is "under way," within the meaning of these rules, when she is not at anchor, or made fast to the shore, or aground.

INLAND RULES

I.—ENACTING CLAUSE, SCOPE, AND PENALTY

Whereas the provisions of chapter eight hundred and two of the laws of eighteen hundred and ninety, and the amendments thereto, adopting regulations for preventing collisions at sea [i.e., international rules of left-hand column], apply to all waters of the United States connected with the high seas navigable by sea-going vessels, except so far as the navigation of any harbor, river, or inland waters is regulated by special rules duly made by local authority; and

Whereas it is desirable that the regulations relating to the navigation of all harbors, rivers, and inland waters of the United States, except the Great Lakes and their connecting and tributary waters as far east as Montreal and the Red River of the North and rivers emptying into the Gulf of Mexico and their tributaries, shall be stated in one act: Therefore,

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled. That the following regulations for preventing collisions shall be followed by all vessels navigating all harbors, rivers, and inland waters of the United States, except the Great Lakes and their connecting and tributary waters as far east as Montreal and the Red River of the North and rivers emptying into the Gulf of Mexico and their tributaries, and are hereby declared special rules duly made by local authority:

SEC. 3. That every pilot, engineer, mate, or master of any steam vessel, and every master or mate of any barge or canal boat, who neglects or refuses to observe the provisions of this act, or the regulations established in pursuance of the preceding section [see section 2, page 4], shall be liable to a penalty of fifty dollars, and for all damages sustained by any passenger in his person or baggage by such neglect or refusal: Provided, That nothing herein shall relieve any vessel, owner, or corporation from any liability incurred by reason of such neglect or refusal.

SEC. 4. That every vessel that shall be navigated without complying with the provisions of this act shall be liable to a penalty of two hundred dollars, one-half to go to the informer, for which sum the vessel so navigated shall be liable and may be seized and proceeded against by action in any district court of the United States having jurisdiction of the offense.

PRELIMINARY DEFINITIONS

In the following rules every steam vessel which is under sail and not under steam is to be considered a sailing vessel, and every vessel under steam whether under sail or not, is to be considered a steam vessel.

The words "steam vessel" shall include any vessel propelled by machinery.

A vessel is "under way," within the meaning of these rules, when she is not at anchor, or made fast to the shore, or aground.

INTERNATIONAL RULES

II.—LIGHTS, AND SO FORTH

The word "visible" in these rules when applied to lights shall mean visible on a dark night with a clear atmosphere.

ARTICLE 1. The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

STEAM VESSELS—MASTHEAD LIGHT

ART. 2. A steam vessel when under way shall carry—(a) On or in front of the foremast, or if a vessel without a foremast, then in the fore part of the vessel, at a height above the hull of not less than twenty feet, and if the breadth of the vessel exceeds twenty feet, then at a height above the hull not less than such breadth, so, however, that the light need not be carried at a greater height above the hull than forty feet, a bright white light, so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

STEAM VESSELS—SIDE LIGHTS

(b) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least two miles.

(c) On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

(d) The said green and red side lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

STEAM VESSELS—RANGE LIGHTS

(e) A steam vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (a). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

INLAND RULES

II.—LIGHTS, AND SO FORTH

The word "visible" in these rules, when applied to lights, shall mean visible on a dark night with a clear atmosphere.

ARTICLE 1. The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

STEAM VESSELS—MASTHEAD LIGHT

ART. 2. A steam vessel when under way shall carry—(a) On or in the front of the foremast, or if a vessel without a foremast, then in the fore part of the vessel, a bright white light so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

STEAM VESSELS—SIDE LIGHTS

(b) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least two miles.

(c) On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

(d) The said green and red side lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

STEAM VESSELS—RANGE LIGHTS

(e) A seagoing steam vessel when under way may carry an additional white light similar in construction to the light mentioned in subdivision (a). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

(f) All steam vessels (except seagoing vessels and ferryboats), shall carry in addition to green and red lights required by article two (b), (c),

INTERNATIONAL RULES

STEAM VESSELS WHEN TOWING

ART. 3. A steam vessel when towing another vessel shall, in addition to her side lights, carry two bright white lights in a vertical line one over the other, not less than six feet apart, and when towing more than one vessel shall carry an additional bright white light six feet above or below such lights, if the length of the tow measuring from the stern of the towing vessel to the stern of the last vessel towed exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in article two (a), excepting the additional light, which may be carried at a height of not less than fourteen feet above the hull.

Such steam vessel may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

SPECIAL LIGHTS

ART. 4. (a) A vessel which from any accident is not under command shall carry at the same height as a white light mentioned in article two (a), where they can best be seen, and if a steam vessel in lieu of that light two red lights, in a vertical line one over the other, not less than six feet apart, and of such a character as to be visible all around the horizon at a distance of at least two miles; and shall by day carry in a vertical line one over the other, not less than six feet apart, where they can best be seen, two black balls or shapes, each two feet in diameter.

(b) A vessel employed in laying or in picking up a telegraph cable shall carry in the same position as the white light mentioned in article two (a), and if a steam vessel in lieu of that light three lights in a vertical line one over the other not less than six feet apart. The highest and lowest of these lights shall be red, and the middle light shall be white, and they shall be of such a character as to be visible all around the horizon, at a distance of at least two miles. By day she shall carry in a vertical line, one over the other, not less than six feet apart, where they can best be seen, three shapes not less than two feet in diameter, of which the highest and lowest shall be globular in shape and red in color, and the middle one diamond in shape and white.

(c) The vessels referred to in this article, when not making way through the water, shall not carry the side lights, but when making way shall carry them.

(d) The lights and shapes required to be shown by this article are to

INLAND RULES

and screens as required by article two (d), a central range of two white lights; the after light being carried at an elevation at least fifteen feet above the light at the head of the vessel. The headlight shall be so constructed as to show an unbroken light through twenty points of the compass, namely from right ahead to two points abaft the beam on either side of the vessel, and the after light so as to show all around the horizon.

STEAM VESSELS WHEN TOWING

ART. 3. A steam vessel when towing another vessel shall, in addition to her side lights, carry two bright white lights in a vertical line one over the other, not less than three feet apart, and when towing more than one vessel shall carry an additional bright white light three feet above or below such lights, if the length of the tow measuring from the stern of the towing vessel to the stern of the last vessel towed exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in article two (a) or the after range light mentioned in article two (f).

Such steam vessel may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

INTERNATIONAL RULES

be taken by other vessels as signals that the vessel showing them is not under command and can not therefore get out of the way.

These signals are not signals of vessels in distress and requiring assistance. Such signals are contained in article thirty-one.

LIGHTS FOR SAILING VESSELS AND VESSELS IN TOW

ART. 5. A sailing vessel under way and any vessel being towed shall carry the same lights as are prescribed by article two for a steam vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

LIGHTS FOR SMALL VESSELS

ART. 6. Whenever, as in the case of small vessels under way during bad weather, the green and red side lights can not be fixed, these lights shall be kept at hand, lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides. To make the use of these portable lights more certain and easy the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

LIGHTS FOR SMALL STEAM AND SAIL VESSELS AND OPEN BOATS

ART. 7. Steam vessels of less than forty, and vessels under oars or sails of less than twenty tons gross tonnage, respectively, and rowing boats, when under way, shall not be required to carry the lights mentioned

INLAND RULES

LIGHTS FOR SAILING VESSELS AND VESSELS IN TOW

ART. 5. A sailing vessel under way or being towed shall carry the same lights as are prescribed by article two for a steam vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

LIGHTS FOR FERRYBOATS, BARGES, AND CANAL BOATS IN TOW

SEC. 2. That the supervising inspectors of steam vessels and the Supervising Inspector-General shall establish such rules to be observed by steam vessels in passing each other and as to the lights to be carried by ferryboats and by barges and canal boats when in tow of steam vessels (and as to the lights and day signals to be carried by vessels, dredges of all types, and vessels working on wrecks by [or] other obstruction to navigation or moored for submarine operations, or made fast to a sunken object which may drift with the tide or be towed) not inconsistent with the provisions of this act, as they from time to time may deem necessary for safety, which rules when approved by the Secretary of Commerce are hereby declared special rules duly made by local authority, as provided for in article thirty of chapter eight hundred and two of the laws of eighteen hundred and ninety. Two printed copies of such rules shall be furnished to such ferryboats (barges, dredges, canal boats, vessels working on wrecks) and steam vessels, which rules shall be kept posted up in conspicuous places in such vessels (barges, dredges, and boats).

LIGHTS FOR SMALL VESSELS

ART. 6. Whenever, as in the case of vessels of less than ten gross tons under way during bad weather, the green and red side lights can not be fixed, these lights shall be kept at hand, lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides. To make the use of these portable lights more certain and easy the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

ART. 7. Rowing boats whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

INTERNATIONAL RULES

in article two (a), (b), and (c), but if they do not carry them they shall be provided with the following lights:

First. Steam vessels of less than forty tons shall carry—

(a) In the fore part of the vessel, or on or in front of the funnel, where it can best be seen, and at a height above the gunwale of not less than nine feet, a bright white light constructed and fixed as prescribed in article two (a), and of such a character as to be visible at a distance of at least two miles.

(b) Green and red side lights constructed and fixed as prescribed in article two (b) and (c), and of such a character as to be visible at a distance of at least one mile, or a combined lantern showing a green light and a red light from right ahead to two points abaft the beam on their respective sides. Such lanterns shall be carried not less than three feet below the white light.

Second. Small steamboats, such as are carried by seagoing vessels, may carry the white light at a less height than nine feet above the gunwale, but it shall be carried above the combined lantern mentioned in subdivision one (b).

Third. Vessels under oars or sails of less than twenty tons shall have ready at hand a lantern with a green glass on one side and a red glass on the other, which, on the approach of or to other vessels, shall be exhibited in sufficient time to prevent collision so that the green light shall not be seen on the port side nor the red light on the starboard side.

Fourth. Rowing boats, whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

The vessels referred to in this article shall not be obliged to carry the lights prescribed by article four (a) and article eleven, last paragraph.

LIGHTS FOR PILOT VESSELS

ART. 8. Pilot vessels when engaged on their station on pilotage duty shall not show the lights required for other vessels, but shall carry a white light at the masthead, visible all around the horizon, and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

On the near approach of or to other vessels they shall have their side lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side, nor the red light on the starboard side.

A pilot vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above mentioned, have at hand, ready for use, a lantern with green glass on the one side and red glass on the other, to be used as prescribed above.

Pilot vessels when not engaged on their station on pilotage duty shall carry lights similar to those of other vessels of their tonnage.

INLAND RULES

LIGHTS FOR PILOT VESSELS

ART. 8. Pilot vessels when engaged on their stations on pilotage duty shall not show the lights required for other vessels, but shall carry a white light at the masthead, visible all around the horizon, and shall also exhibit a flare-up light or flare-up lights at short intervals, which shall never exceed fifteen minutes.

On the near approach of or to other vessels they shall have their side lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side nor the red light on the starboard side.

A pilot vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above mentioned, have at hand, ready for use, a lantern with a green glass on the one side and a red glass on the other, to be used as prescribed above.

Pilot vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

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A steam pilot vessel, when engaged on her station on pilotage duty and in waters of the United States, and not at anchor, shall, in addition to the lights required for all pilot boats, carry at a distance of eight feet below her white masthead light a red light, visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored side lights required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and at anchor, she shall carry in addition to the lights required for all pilot boats the red light above mentioned, but not the colored side lights. When not engaged on her station on pilotage duty, she shall carry the same lights as other steam vessels.

LIGHTS, ETC., OF FISHING VESSELS

ART. 9. Fishing vessels and fishing boats, when under way and when not required by this article to carry or show the lights hereinafter specified, shall carry or show the lights prescribed for vessels of their tonnage under way.

(a) Open boats, by which is to be understood boats not protected from the entry of sea water by means of a continuous deck, when engaged in any fishing at night, with outlying tackle extending not more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry one all-round white light.

Open boats, when fishing at night, with outlying tackle extending more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry one all-round white light, and in addition, on approaching or being approached by other vessels, shall show a second white light at least three feet below the first light and at a horizontal distance of at least five feet away from it in the direction in which the outlying tackle is attached.

(b) Vessels and boats, except open boats as defined in subdivision (a), when fishing with drift nets, shall, so long as the nets are wholly or partly in the water, carry two white lights where they can best be seen. Such lights shall be placed so that the vertical distance between them shall be not less than six feet and not more than fifteen feet, and so that the horizontal distance between them, measured in a line with the keel, shall be not less than five feet and not more than ten feet. The lower of these two lights shall be in the direction of the nets, and both of them shall be of such a character as to show all around the horizon, and to be visible at a distance of not less than three miles.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the net or gear) a white light, visible at a distance of not less than one sea mile, on the approach of or to other vessels.

INLAND RULES

A steam pilot vessel, when engaged on her station on pilotage duty and in waters of the United States, and not at anchor, shall, in addition to the lights required for all pilot boats, carry at a distance of eight feet below her white masthead light a red light, visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored side lights required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and at anchor, she shall carry in addition to the lights required for all pilot boats the red light above mentioned, but not the colored side lights. When not engaged on her station on pilotage duty, she shall carry the same lights as other steam vessels.

LIGHTS, ETC., OF FISHING VESSELS

ART. 9. (a) Fishing vessels of less than ten gross tons, when under way and when not having their nets, trawls, dredges, or lines in the water, shall not be obliged to carry the colored side lights; but every such vessel shall, in lieu thereof, have ready at hand a lantern with a green glass on one side and a red glass on the other side, and on approaching to or being approached by another vessel such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

(b) All fishing vessels and fishing boats of ten gross tons or upward, when under way and when not having their nets, trawls, dredges, or lines in the water, shall carry and show the same lights as other vessels under way.

(c) All vessels, when trawling, dredging, or fishing with any kind of drag nets or lines, shall exhibit from some part of the vessel where they can be best seen, two lights. One of these lights shall be red and the other shall be white. The red light shall be above the white light, and shall be at a vertical distance from it of not less than six feet and not more than twelve feet; and the horizontal distance between them, if any, shall not be more than ten feet. These two lights shall be of such a character and contained in lanterns of such construction as to be visible all around the horizon, the white light a distance of not less than three miles and the red light of not less than two miles.

LIGHTS FOR RAFTS OR OTHER CRAFT NOT PROVIDED FOR

(d) Rafts, or other water craft not herein provided for, navigating by hand power, horse power, or by the current of the river, shall carry one or more good white lights, which shall be placed in such manner as shall be prescribed by the Board of Supervising Inspectors of Steam Vessels.

RULE FOR VESSELS WHICH ARE MOORED OR AT ANCHOR

Vessels propelled by machinery which are moored or anchored shall

INTERNATIONAL RULES

(c) Vessels and boats, except open boats as defined in subdivision (a), when line fishing with their lines out and attached to or hauling their lines, and when not at anchor or stationary within the meaning of subdivision (h), shall carry the same lights as vessels fishing with drift nets. When shooting lines, or fishing with towing lines, they shall carry the lights prescribed for a steam or sailing vessel under way, respectively.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the lines) a white light, visible at a distance of not less than one sea mile on the approach of or to other vessels.

(d) Vessels when engaged in trawling, by which is meant the dragging of an apparatus along the bottom of the sea—

First, if steam vessels, shall carry in the same position as the white light mentioned in article two (a) a tri-colored lantern so constructed and fixed as to show a white light from right ahead to two points on each bow, and a green light and a red light over an arc of the horizon from two points on each bow to two points abaft the beam on the starboard and port sides, respectively; and not less than six nor more than twelve feet below the tri-colored lantern a white light in a lantern, so constructed as to show a clear, uniform and unbroken light all around the horizon.

Second, if sailing vessels, shall carry a white light in a lantern, so constructed as to show a clear, uniform, and unbroken light all around the horizon, and shall also, on the approach of or to other vessels, show where it can best be seen a white flare-up light or torch in sufficient time to prevent collision.

All lights mentioned in subdivision (d) first and second shall be visible at a distance of at least two miles.

(e) Oyster dredgers and other vessels fishing with dredge nets shall carry and show the same lights as trawlers.

(f) Fishing vessels and fishing boats may at any time use a flare-up light in addition to the lights which they are by this article required to carry and show, and they may also use working lights.

(g) Every fishing vessel and every fishing boat under one hundred and fifty feet in length, when at anchor, shall exhibit a white light visible all around the horizon at a distance of at least one mile.

Every fishing vessel of one hundred and fifty feet in length or upward, when at anchor, shall exhibit a white light visible all around the horizon at a distance of at least one mile, and shall exhibit a second light as provided for vessels of such length by article eleven.

Should any such vessel, whether under one hundred and fifty feet in length or of one hundred and fifty feet in length or upward, be attached to a net or other fishing gear, she shall on the approach of other vessels show an additional white light at least three feet below the anchor light, and at a horizontal distance of at least five feet away from it in the direction of the net or gear.

INLAND RULES

display by day forward where it can be best seen one black ball or shape not less than 2 feet in diameter.

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(h) If a vessel or boat when fishing becomes stationary in consequence of her gear getting fast to a rock or other obstruction, she shall in daytime haul down the day signal required by subdivision (k); at night show the light or lights prescribed for a vessel at anchor; and during fog, mist, falling snow, or heavy rain storms make the signal prescribed for a vessel at anchor. (See subdivision (d) and the last paragraph of article fifteen.)

(i) In fog, mist, falling snow, or heavy rain storms drift-net vessels attached to their nets, and vessels when trawling, dredging, or fishing with any kind of drag net, and vessels line fishing with their lines out, shall, if of twenty tons gross tonnage or upward, respectively, at intervals of not more than one minute make a blast; if steam vessels, with the whistle or siren, and if sailing vessels, with the fog-horn, each blast to be followed by ringing the bell. Fishing vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals; but if they do not, they shall make some other efficient sound signal at intervals of not more than one minute.

(k) All vessels or boats fishing with nets or lines or trawls, when under way, shall in daytime indicate their occupation to an approaching vessel by displaying a basket or other efficient signal where it can best be seen. If vessels or boats at anchor have their gear out, they shall, on the approach of other vessels, show the same signal on the side on which those vessels can pass.

The vessels required by this article to carry or show the lights hereinbefore specified shall not be obliged to carry the lights prescribed by article four (a) and the last paragraph of article eleven.

LIGHTS FOR AN OVERTAKEN VESSEL

ART. 10. A vessel which is being overtaken by another shall show from her stern to such last-mentioned vessel a white light or a flare-up light.

The white light required to be shown by this article may be fixed and carried in a lantern, but in such case the lantern shall be so constructed, fitted, and screened that it shall throw an unbroken light over an arc of the horizon of twelve points of the compass, namely, for six points from right aft on each side of the vessel, so as to be visible at a distance of at least one mile. Such light shall be carried as nearly as practicable on the same level as the side lights.

ANCHOR LIGHTS

ART. 11. A vessel under one hundred and fifty feet in length when at anchor shall carry forward, where it can best be seen, but at a height not exceeding twenty feet above the hull, a white light, in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile.

A vessel of one hundred and fifty feet or upwards in length when at anchor shall carry in the forward part of the vessel, at a height of not less than twenty and not exceeding forty feet above the hull, one such light,

INLAND RULES

LIGHTS FOR AN OVERTAKEN VESSEL

ART. 10. A vessel which is being overtaken by another, except a steam vessel with an after range light showing all around the horizon, shall show from her stern to such last-mentioned vessel a white light or a flare-up light.

ANCHOR LIGHTS

ART. 11. A vessel under one hundred and fifty feet in length when at anchor shall carry forward, where it can best be seen, but at a height not exceeding twenty feet above the hull, a white light, in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile.

A vessel of one hundred and fifty feet or upwards in length when at anchor shall carry in the forward part of the vessel, at a height of not less than twenty and not exceeding forty feet above the hull, one such light,

and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, another such light.

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

A vessel aground in or near a fairway shall carry the above light or lights and the two red lights prescribed by article four (a).

SPECIAL SIGNALS

ART. 12. Every vessel may, if necessary, in order to attract attention, in addition to the lights which she is by these rules required to carry, show a flare-up light or use any detonating signal that can not be mistaken for a distress signal.

NAVAL LIGHTS AND RECOGNITION SIGNALS

ART. 13. Nothing in these rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal lights for two or more ships of war or for vessels sailing under convoy, or with the exhibition of recognition signals adopted by shipowners, which have been authorized by their respective Governments and duly registered and published.

STEAM VESSEL UNDER SAIL BY DAY

ART. 14. A steam vessel proceeding under sail only, but having her funnel up, shall carry in daytime, forward, where it can best be seen, one black ball or shape two feet in diameter.

III. SOUND SIGNALS FOR FOG, AND SO FORTH

PRELIMINARY

ART. 15. All signals prescribed by this article for vessels under way shall be given:

First. By "steam vessels" on the whistle or siren.

Second. By "sailing vessels" and "vessels towed" on the fog horn.

The words "prolonged blast" used in this article shall mean a blast of from four to six second's duration.

A steam vessel shall be provided with an efficient whistle or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog horn, to be sounded by mechanical means, and also with an efficient bell. In all cases where the rules require a bell to be used a drum may be substituted on board Turkish vessels, or a gong where such articles are used on board small seagoing vessels. A sailing vessel of twenty tons gross tonnage or upward shall be provided with a similar fog horn and bell.

In a fog, mist, falling snow, or heavy rain storms, whether by day or night, the signals described in this article shall be used as follows, namely:

and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, another such light.

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

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2. By "sailing vessels" and "vessels towed" on the fog horn.

The words "prolonged blast" used in this article shall mean a blast of from four to six second's duration.

A steam vessel shall be provided with an efficient whistle or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog horn; also with an efficient bell. A sailing vessel of twenty tons gross tonnage or upward shall be provided with a similar fog horn and bell.

In fog, mist, falling snow, or heavy rain storms, whether by day or night, the signals described in this article shall be used as follows, namely:

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STEAM VESSEL UNDER WAY

(a) A steam vessel having way upon her shall sound, at intervals of not more than two minutes, a prolonged blast.

(b) A steam vessel under way, but stopped, and having no way upon her, shall sound, at intervals of not more than two minutes, two prolonged blasts, with an interval of about one second between.

SAILING VESSEL UNDER WAY

(c) A sailing vessel under way shall sound, at intervals of not more than one minute, when on the starboard tack, one blast; when on the port tack, two blasts in succession, and when with the wind abaft the beam, three blasts in succession.

VESSELS AT ANCHOR OR NOT UNDER WAY

(d) A vessel when at anchor shall, at intervals of not more than one minute, ring the bell rapidly for about five seconds.

VESSELS TOWING OR TOWED

(e) A vessel when towing, a vessel employed in laying or in picking up a telegraph cable, and a vessel under way, which is unable to get out of the way of an approaching vessel through being not under command, or unable to maneuver as required by the rules, shall, instead of the signals prescribed in subdivisions (a) and (c) of this article, at intervals of not more than two minutes, sound three blasts in succession, namely: One prolonged blast followed by two short blasts. A vessel towed may give this signal and she shall not give any other.

SMALL SAILING VESSELS AND BOATS

Sailing vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals, but, if they do not, they shall make some other efficient sound signal at intervals of not more than one minute.

SPEED IN FOG

ART. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rain storms, go at a moderate speed, having careful regard to the existing circumstances and conditions.

A steam vessel hearing, apparently forward of her beam, the fog signal of a vessel the position of which is not ascertained shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.

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STEAM VESSEL UNDER WAY

(a) A steam vessel under way shall sound, at intervals of not more than one minute, a prolonged blast.

SAILING VESSELS UNDER WAY

(c) A sailing vessel under way shall sound, at intervals of not more than one minute, when on the starboard tack, one blast; when on the port tack, two blasts in succession, and when with the wind abaft the beam, three blasts in succession.

VESSELS AT ANCHOR OR NOT UNDER WAY

(d) A vessel when at anchor shall, at intervals of not more than one minute, ring the bell rapidly for about five seconds.

VESSELS TOWING OR TOWED

(e) A steam vessel, when towing, shall, instead of the signals prescribed in subdivision (a) of this article, at intervals of not more than one minute, sound three blasts in succession, namely, one prolonged blast followed by two short blasts. A vessel towed may give this signal and she shall not give any other.

RAFTS, OR OTHER CRAFT NOT PROVIDED FOR

(f) All rafts or other water craft, not herein provided for, navigating by hand power, horse power, or by the current of the river, shall sound a blast of the fog horn, or equivalent signal, at intervals of not more than one minute.

SPEED IN FOG

ART. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rain storms, go at a moderate speed, having careful regard to the existing circumstances and conditions.

A steam vessel hearing, apparently forward of her beam, the fog signal of a vessel the position of which is not ascertained shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.

INTERNATIONAL RULES

IV. STEERING AND SAILING RULES

PRELIMINARY

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change, such risk should be deemed to exist.

SAILING VESSELS

ART. 17. When two sailing vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other, as follows, namely:

(a) A vessel which is running free shall keep out of the way of a vessel which is closehauled.

(b) A vessel which is closehauled on the port tack shall keep out of the way of a vessel which is closehauled on the starboard tack.

(c) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(d) When both are running free, with the wind on the same side, the vessel which is to the windward shall keep out of the way of the vessel which is to the leeward.

(e) A vessel which has the wind aft shall keep out of the way of the other vessel.

STEAM VESSELS

ART. 18. When two steam vessels are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other.

This article only applies to cases where vessels are meeting end on, or nearly end on, in such a manner as to involve risk of collision, and does not apply to two vessels which must, if both keep on their respective courses, pass clear of each other.

The only cases to which it does apply are when each of the two vessels is end on, or nearly end on to the other; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own; and by night, to cases in which each vessel is in such a position as to see both the side-lights of the other.

It does not apply by day to cases in which a vessel sees another ahead crossing her own course; or by night, to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light, or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

INLAND RULES

IV.—STEERING AND SAILING RULES

PRELIMINARY

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change, such risk should be deemed to exist.

SAILING VESSELS

ART. 17. When two sailing vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other as follows, namely:

(a) A vessel which is running free shall keep out of the way of a vessel which is closehauled.

(b) A vessel which is closehauled on the port tack shall keep out of the way of a vessel which is closehauled on the starboard tack.

(c) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(d) When both are running free, with the wind on the same side, the vessel which is to the windward shall keep out of the way of the vessel which is to the leeward.

(e) A vessel which has the wind aft shall keep out of the way of the other vessel.

STEAM VESSELS

ART. 18. RULE I. When steam vessels are approaching each other head and head, that is, end on, or nearly so, it shall be the duty of each to pass on the port side of the other; and either vessel shall give, as a signal of her intention, one short and distinct blast of her whistle, which the other vessel shall answer promptly by a similar blast of her whistle, and thereupon such vessels shall pass on the port side of each other. But if the courses of such vessels are so far on the starboard of each other as not to be considered as meeting head and head, either vessel shall immediately give two short and distinct blasts of her whistle, which the other vessel shall answer promptly by two similar blasts of her whistle, and they shall pass on the starboard side of each other.

The foregoing only applies to cases where vessels are meeting end on, or nearly end on, in such a manner as to involve risk of collision; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own, and by night to cases in which each vessel is in such a position as to see both the sidelights of the other.

It does not apply by day to cases in which a vessel sees another ahead crossing her own course, or by night to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of

INTERNATIONAL RULES

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one vessel is opposed to the green light of the other, or where a red light without a green light or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

RULE III. If, when steam vessels are approaching each other, either vessel fails to understand the course or intention of the other, from any cause, the vessel so in doubt shall immediately signify the same by giving several short and rapid blasts, not less than four, of the steam whistle.

RULE V. Whenever a steam vessel is nearing a short bend or curve in the channel, where, from the height of the banks or other cause, a steam vessel approaching from the opposite direction can not be seen for a distance of half a mile, such steam vessel, when she shall have arrived within half a mile of such curve or bend, shall give a signal by one long blast of the steam whistle, which signal shall be answered by a similar blast given by any approaching steam vessel that may be within hearing. Should such signal be so answered by a steam vessel upon the farther side of such bend, then the usual signals for meeting and passing shall immediately be given and answered; but, if the first alarm signal of such vessel be not answered, she is to consider the channel clear and govern herself accordingly.

When steam vessels are moved from their docks or berths, and other boats are liable to pass from any direction toward them, they shall give the same signal as in the case of vessels meeting at a bend, but immediately after clearing the berths so as to be fully in sight they shall be governed by the steering and sailing rules.

RULE VIII. When steam vessels are running in the same direction, and the vessel which is astern shall desire to pass on the right or starboard hand of the vessel ahead, she shall give one short blast of the steam whistle, as a signal of such desire, and if the vessel ahead answers with one blast, she shall put her helm to port; or if she shall desire to pass on the left or port side of the vessel ahead, she shall give two short blasts of the steam whistle as a signal of such desire, and if the vessel ahead answers with two blasts, shall put her helm to starboard; or if the vessel ahead does not think it safe for the vessel astern to attempt to pass at that point, she shall immediately signify the same by giving several short and rapid blasts of the steam whistle, not less than four, and under no circumstances shall the vessel astern attempt to pass the vessel ahead until such time as they have reached a point where it can be safely done, when said vessel ahead shall signify her willingness by blowing the proper signals. The vessel ahead shall in no case attempt to cross the bow or crowd upon the course of the passing vessel.

RULE IX. The whistle signals provided in the rules under this article, for steam vessels meeting, passing, or overtaking, are never to be used except when steamers are in sight of each other, and the course and position of each can be determined in the daytime by a sight of the vessel itself, or by night by seeing its signal lights. In fog, mist, falling snow or heavy rain storms, when vessels can not see each other, fog signals only must be given.

INTERNATIONAL RULES

TWO STEAM VESSELS CROSSING

ART. 19. When two steam vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

STEAM VESSEL SHALL KEEP OUT OF THE WAY OF SAILING VESSEL

ART. 20. When a steam vessel and a sailing vessel are proceeding in such directions as to involve risk of collision, the steam vessel shall keep out of the way of the sailing vessel.

COURSE AND SPEED

ART. 21. Where, by any of these rules, one of two vessels is to keep out of the way the other shall keep her course and speed.

Note—When, in consequence of thick weather or other causes, such vessel finds herself so close that collision can not be avoided by the action of the giving-way vessel alone, she also shall take such action as will best aid to avert collision. [See articles twenty-seven and twenty-nine.]

CROSSING AHEAD

ART. 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, avoid crossing ahead of the other.

STEAM VESSEL SHALL SLACKEN SPEED OR STOP

ART. 23. Every steam vessel which is directed by these rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

OVERTAKING VESSELS

ART. 24. Notwithstanding anything contained in these rules every vessel, overtaking any other, shall keep out of the way of the overtaken vessel.

INLAND RULES

SUPPLEMENTARY REGULATIONS

SEC. 2. That the supervising inspectors of steam vessels and the Supervising Inspector-General shall establish such rules to be observed by steam vessels in passing each other and as to the lights to be carried by ferryboats and by barges and canal boats when in tow of steam vessels, not inconsistent with the provisions of this act, as they from time to time may deem necessary for safety, which rules when approved by the Secretary of Commerce are hereby declared special rules duly made by local authority, as provided for in article thirty of chapter eight hundred and two of the laws of eighteen hundred and ninety. Two printed copies of such rules shall be furnished to such ferryboats, and steam vessels which rules shall be kept posted up in conspicuous places in such vessels.

TWO STEAM VESSELS CROSSING

ART. 19. When two steam vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

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[See articles twenty-seven and twenty-nine.]

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STEAM VESSEL SHALL SLACKEN SPEED OR STOP

ART. 23. Every steam vessel which is directed by these rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

OVERTAKING VESSELS

ART. 24. Notwithstanding anything contained in these rules every vessel, overtaking any other, shall keep out of the way of the overtaken vessel.

INTERNATIONAL RULES

Every vessel coming up with another vessel from any direction more than two points abaft her beam, that is, in such a position, with reference to the vessel which she is overtaking that at night she would be unable to see either of that vessel's side lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

As by day the overtaking vessel can not always know with certainty whether she is forward of or abaft this direction from the other vessel she should, if in doubt, assume that she is an overtaking vessel and keep out of the way.

NARROW CHANNELS

ART. 25. In narrow channels every steam vessel shall, when it is safe and practicable, keep to that side of the fairway or mid-channel which lies on the starboard side of such vessel.

RIGHT OF WAY OF FISHING VESSELS

ART. 26. Sailing vessels under way shall keep out of the way of sailing vessels or boats fishing with nets, or lines, or trawls. This rule shall not give to any vessel or boat engaged in fishing the right of obstructing a fairway used by vessels other than fishing vessels or boats.

GENERAL PRUDENTIAL RULE

ART. 27. In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

SOUND SIGNALS FOR PASSING STEAMERS

ART. 28. The words "short blast" used in this article shall mean a blast of about one second's duration.

When vessels are in sight of one another, a steam vessel under way, in taking any course authorized or required by these rules, shall indicate that course by the following signals on her whistle or siren, namely:

One short blast to mean, "I am directing my course to starboard."

Two short blasts to mean, "I am directing my course to port."

Three short blasts to mean, "My engines are going at full speed astern."

PRECAUTION

ART. 29. Nothing in these rules shall exonerate any vessel, or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or

INLAND RULES

Every vessel coming up with another vessel from any direction more than two points abaft her beam, that is, in such a position, with reference to the vessel which she is overtaking that at night she would be unable to see either of that vessel's side lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

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SOUND SIGNALS FOR PASSING STEAMERS

[See article eighteen.]

ART. 28. When vessels are in sight of one another a steam vessel under way whose engines are going at full speed astern shall indicate that fact by three short blasts on the whistle.

PRECAUTION

ART. 29. Nothing in these rules shall exonerate any vessel, or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or

INTERNATIONAL RULES

of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

ART. 30. [See page 2.]

DISTRESS SIGNALS

ART. 31. When a vessel is in distress and requires assistance from other vessels or from the shore the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the daytime—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. The international code signal of distress indicated by N. C.

Third. The distance signal, consisting of a square flag, having either above or below it a ball or anything resembling a ball.

Fourth. A continuous sounding with any fog-signal apparatus.

At night—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. Flames on the vessel (as from a burning tar barrel, oil barrel, and so forth).

Third. Rockets or shells throwing stars of any color or description, fired one at a time, at short intervals.

Fourth. A continuous sounding with any fog-signal apparatus.

INLAND RULES

of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

LIGHTS ON UNITED STATES NAVAL VESSELS AND REVENUE CUTTERS

ART. 30. The exhibition of any light on board of a vessel of war of the United States or a Coast Guard cutter may be suspended whenever, in the opinion of the Secretary of the Navy, the commander in chief of a squadron, or the commander of a vessel acting singly, the special character of the service may require it.

DISTRESS SIGNALS

ART. 31. When a vessel is in distress and requires assistance from other vessels or from the shore the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the daytime—

A continuous sounding with any fog-signal apparatus, or firing a gun.

At night—

First. Flames on the vessel as from a burning tar barrel, oil barrel, and so forth.

Second. A continuous sounding with any fog-signal apparatus, or firing a gun.

CHAPTER II

DECK OFFICER'S INFORMATION

NAVIGATION DEFINITIONS AND ACCESSORIES, AND GENERAL INFORMATION

Part I

Altitude.—The "Observed Altitude" is the angular height of a heavenly body above the horizon, measured by a sextant.

The "Apparent Altitude" is the observed altitude corrected for sextant error (if any); height of eye; and in the case of the sun observed for semidiameter.

The "True Altitude" is the apparent altitude corrected for refraction, and, in case of the sun, observed for parallax.

The "Meridian Altitude" is the angular height of a heavenly body above the horizon at the time the body is crossing the meridian of the observer, or the highest point which that body will reach on that day.

Amplitude.—The bearing (never exceeding 90°) of a heavenly body at rising or setting. It is calculated from the east point when the body is rising, from the west point when setting.

Angle.—The inclination to each other, in a plane, of two lines which meet each other, and do not lie straight with respect to each other. When the sides of an angle are perpendicular to each other, it is a **right angle**; when less than a right angle, an **acute angle**; when greater than a right angle, an **obtuse angle**; when the sides go out in opposite directions, a **straight angle.** Any angle not a right or straight angle is an **oblique angle.**

Apparent Time.—Is time calculated by the sun. When the sun crosses the meridian of the observer it is apparent noon where he is as well as at all places on his meridian from pole to pole.

Astronomical Day.—A mean solar day, reckoned from noon to noon.

Average.—When it is found necessary to jettison cargo, and some shipper's cargo is sacrificed to save the rest of the cargo and ship, a general average is made out so that each should pay their proportionate part.

"General Average" is where the loss falls on the value of the ship, freight and cargo. (All parties concerned.)

"Particular Average" is where the loss falls on the ship, the cargo or the freight, and which cannot be held as a loss for the benefit of all concerned. (Any damage or loss insured against.)

To bring a loss under general average it must be a voluntary sacrifice; that is, the master, after consulting the officers and crew, deliberately orders the cargo to be thrown overboard or anything necessary to save the ship. Therefore, it must be an absolute necessity for this action in order to save the ship.

Axis.—An imaginary line about which a body or system of bodies rotates.

Azimuth.—The bearing (never exceeding 180°) of a heavenly body. It is calculated from the north and south points, according to latitude of observer, through east when body is rising; through west when setting.

Bankrupt.—(Q) If you were in a foreign port and your owners are bankrupt, who is responsible for disbursements transacted abroad? (A) The master, who in all probability will be sued for the amount, and under such circumstances the master can put a writ or lien on the vessel until some interested party paid the claim.

Barometer.—The "Mercurial Barometer" is an instrument used for determining at any time the weight or pressure of the atmosphere in its immediate vicinity. It is made by taking a glass tube sealed at one end, and placing the other end in a receptacle containing mercury. The mercury will then descend the tube until the weight of the column of mercury in the tube is balanced by the atmospheric pressure or weight on the mercury in the cup. The glass tube is graduated in proper ratio, so that the increase or decrease of pressure can be read on the scale at the side of the glass.

The "Aneroid Barometer" is another type, which, owing to its compact form, and the fact that no liquid is used, is coming into use more and more for sea service. The varying pressure of the atmosphere is registered on the dial by a hand, which is controlled by the expansion or contraction

of a metal box, generally of a circular form with corrugated surface, from which almost all air has been withdrawn, leaving a partial vacuum.

The instruments should not be removed from the ship, but frequent comparisons should be made to ascertain error of instrument by reading barometer at 12-hour intervals three times (8 A. M. or noon preferable) and forwarding same to local weather bureau.

Barratry.—Any fraudulent act committed by the master or any of the crew.

Bill of Lading.—A receipt for cargo received on board the ship, also an agreement to deliver such goods at some other port in the same order and condition they were received, for a certain amount stipulated on the bill of lading. Usually three copies are made, one for shipper of goods, one for consignee, and one for the master. All are signed by the master, owner or authorized agent.

Binnacles.—Compasses are mounted for use in stands known as Binnacles, of which there are two principal types—the Compensating and the Non-Compensating Binnacle, so designated according as they are or are not equipped with appliances by which the deviation of the compass, or error in its indications due to disturbing magnetic features within the ship, may be compensated.

Binnacles may be of wood or of some non-magnetic metal; all contain a compass chamber within which the compass is suspended in its gimbal ring, the knife edges upon which it is suspended resting in V-shaped bearings; an appropriate method is supplied for centering the compass. A hood is provided for the protection of the compass and for lighting it at night. Binnacles must be rigidly secured to the deck of the vessel in such position that the lubber's line of the compass gives true indications of the direction of the ship's head.

The position of the various binnacles on shipboard and the height at which they carry the compass must be chosen with regard to the purpose which the compass is to serve, having in mind the magnetic conditions of the ship.

Compensating binnacles contain the appliances for carrying the various correctors used in the compensation of the deviation of the compass. These consist of (*a*) a system of permanent magnets for semicircular deviation, placed in a magnet chamber lying immediately beneath the compass chamber, so arranged as to permit variation in the height

and direction of the magnets employed; (*b*) a pair of arms projecting horizontally from the compass chamber and supporting masses of soft iron for quadrantal deviation; (*c*) a central tube in the vertical axis of the binnacle for a permanent magnet used to correct the heeling error, and (*d*) an attachment, sometimes fitted, for securing a vertical soft iron rod, or "Flinder's bar," used in certain cases for correction of a part of the semicircular deviation. (See Compass Adjustment.)

Boat in a Heavy Surf.—(Q) How would you handle it? (A) I would head my boat to the sea and pull towards it when it breaks. If about to beach a boat in the surf pull in close to the breakers, then back the boat in, pulling toward the sea as it breaks. Do not let her fall broadside too, or the boat will swamp.

Bottomry Bond.—A contract by which the master or owner of a vessel gives the vessel as security for money loaned to enable the ship to complete the voyage. No law regulates the interest on money loaned in this manner, and if the ship is lost before completing her voyage the lender loses the money loaned.

Buoyage System of U. S.—On entering channels nun-shaped or peaked buoys, red with even numbers, starboard side. Can-shaped or flat-top buoys, black with odd numbers, port side. Black and white perpendicular striped buoys are fairway buoys. Black and red horizontal striped buoys are obstruction buoys, give berth on both sides. White buoys are anchorage ground, anchor inside of buoys. Gas, bell and whistling buoys are colored and placed according to the needs of surroundings and locality and are described in local buoy books. Buoys and beacons with cages are generally placed at turns in narrow channels, and may be colored with reference to background.

Chain Shackles.—(Q) How should they be installed? (A) The round end toward the hawse so it will not get jammed in letting go the anchor.

Chart.—The chart should be carefully studied, and among other things all of its notes should be read, as valuable information may be given in the margin which it is not practicable to place upon the chart abreast the locality affected.

The mariner will do well to consider the source of his chart and the authority upon which it is based. He will naturally feel the greatest confidence in a chart issued by

the Government of one of the more important maritime nations which maintains a well-equipped office for the especial purpose of acquiring and treating hydrographic information. He should note the character of the survey from which the chart has been constructed; and, finally, he should be especially careful that the chart is of recent issue or bears correction of a recent date—facts that should always be clearly shown upon its face.

It is well to proceed with caution when the chart of the locality is based upon an old survey, or one whose source does not carry with it the presumption of accuracy. Even if the original survey was a good one, a sandy bottom, in a region where the currents are strong or the seas heavy, is liable to undergo in time marked changes; and where the depth is affected by the deposit or removal of silt, as in the vicinity of the estuaries of large river systems, the behavior is sometimes most capricious. Large blank spaces on the chart, where no soundings are shown, may be taken as an indication that no soundings were made, and are to be regarded with suspicion, especially if the region abounds in reefs or pinnacle rocks, in which case only the closest sort of a survey can be considered as revealing all the dangers. All of these facts must be duly weighed.

When navigating by landmarks the chart of the locality which is on the largest scale should be used. The hydrography and topography in such charts appear in greater detail, and—a most important consideration—bearings and angles may be plotted with increased accuracy. (See Mercator; Polyconic; Gnomonic Chart.)

Charter Party.—An agreement in writing between the owner or master and the charterer that the vessel shall perform a certain service for which her owner shall receive a certain consideration.

The principal clauses are voyage; freight; layday; demurrage; liberty to tow and assist vessels; penalties for non-performance; as near the port as she can safely get; always afloat; and various other clauses according to the nature of the voyage.

The penalty is the estimated amount of freight.

Chronometer.—A correct time-measurer, differing from an ordinary watch in having the force of its main-spring rendered uniform by means of a variable lever. Owing to the fact that on a sea voyage a chronometer is exposed to many changes of temperature, it is furnished with an expan-

sion balance, formed of a combination of metals of different expansive qualities, which produces the required compensation. In order that its working may not be deranged by the motion of the ship in a seaway, the instrument is carried in gimbals.

It is set to the time of some first meridian. The Americans and English use the time of the meridian of Greenwich.

Civil Day and Time.—The civil day commences at midnight and comprises the 24 hours until the following midnight. The civil day is divided into two parts of 12 hours each. The first which is marked A. M. (Ante Meridian), the last P. M. (Post Meridian). It is the time that all watches and clocks are set to.

Clinometer.—An instrument used for registering the amount of list or heel, generally to be found on the binnacle. As one degree of list will frequently alter the deviation to a like amount, this will require careful watching. It also comes in handy when putting ship in dry-dock to ascertain if ship is upright.

Clouds.—The following are the principal forms of clouds, named in the order of the altitude above the earth at which they usually occur, beginning with the most elevated. The symbols by which each is designated follows its name:

1. **Cirrus,** (Ci.).—Detached clouds, delicate and fibrous looking, taking the form of feathers, generally of a white color, sometimes arranged in belts which cross a portion of the sky in great circles, and, by an effect of perspective, converging toward one or two opposite points of the horizon.

2. **Cirro-Stratus,** (Ci.-S.).—A thin, whitish sheet, sometimes completely covering the sky and only giving it a whitish appearance, or at others presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the sun or moon.

3. **Cirro-Cumulus,** (Ci.-Cu.).—Small globular masses or white flakes, having no shadows, or only very light shadows, arranged in groups and often in lines.

4. **Alto-Cumulus,** (A.-Cu.).—Rather large globular masses, white or grayish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused. The detached masses are generally larger and more compact at the center of the group; at the margin they form into finer flakes. They often spread themselves out in lines in one or two directions.

5. Alto-Stratus, (A.-S.).—A thick sheet of a gray or bluish color, showing a brilliant patch in the neighborhood of the sun or moon, and which, without causing halos, may give rise to coronae. This form goes through all the changes like the Cirro-Stratus, but its altitude is only half so great.

6. Strato-Cumulus, (S.-Cu.).—Large globular masses or rolls of dark cloud, frequently covering the whole sky, especially in winter, and occasionally giving it a wavy appearance. The layer of Strato-Cumulus is not, as a rule, very thick, and patches of blue sky are often visible through the intervening spaces. All sorts of transitions between this form and the Alto-Cumulus are noticeable. It may be distinguished from Nimbus by its globular or rolled appearance and also because it does not bring rain.

7. Nimbus, (N.).—Rain clouds; a thick layer of dark clouds, without shape and with ragged edges, from which continued rain or snow generally falls. Through the openings of these clouds an upper layer of Cirro-Stratus or Alto-Stratus may almost invariably be seen. If the layer of Nimbus separates into shreds or if small loose clouds are visible floating at a low level underneath a large nimbus, they may be described as Fracto-Nimbus (Fr.-N.), the "scud" of sailors.

8. Cumulus, (Cu.).—Wool-pack clouds; thick clouds of which the upper surface is dome-shaped and exhibits protuberances, while the base is horizontal. When these clouds are opposite the sun the surfaces usually presented to the observer have a greater brilliance than the margins of the protuberances. When the light falls aslant, they give deep shadows; when, on the contrary, the clouds are on the same side as the sun, they appear dark, with bright edges. The true Cumulus has clear superior and inferior limits. It is often broken up by strong winds, and the detached portions undergo continual changes. These may be distinguished by the name of Fracto-Cumulus (Fr.-Cu.).

9. Cumulo-Nimbus, (Cu.-N.).—The thunder-cloud or shower-cloud; heavy masses of clouds rising in the form of mountains, turrets, or anvils, generally having a sheet or screen of fibrous appearance above, and a mass of clouds similar to Nimbus underneath. From the base there usually fall local showers of rain or of snow (occasionally hail or soft hail).

10. Stratus, (S.).—A horizontal sheet of lifted fog; when this sheet is broken up into irregular shreds by the wind or

by the summits of mountains, it may be distinguished by the name of Fracto-Stratus, (Fr.-S.).

Compass.—The mariner's compass is an instrument by means of which the directive force of that great magnet, the Earth, upon a freely-suspended needle, is utilized for the purpose of navigation. The needle is so mounted that it only moves freely in the horizontal plane, and therefore the horizontal component of the earth's force alone directs it. The direction assumed by the needle is not generally toward the geographical north, but diverges toward the east or west of it, making a horizontal angle with the true meridian, known as the variation of the compass. The card is marked with the outer margin divided into degrees with 0° at north and south, and 90° at east and west (some compasses are marked from 0° to 360°); the 32 points with half and quarter points are seen immediately within the degrees. (See illustration and table for compass points.)

The standard compass is usually located in the ship in the central fore-and-aft line which is established from the builder's marks placed in that vicinity, and it should be so laid that the north point of the needle should be strictly in line with the keel of the ship. It should be easily accessible at all times, raised to such a height as to permit bearings to be conveniently observed, and as far as possible from dynamos and any considerable mass of iron, especially if vertical.

Compass Adjustment.—Strip compass of all magnets. Suppose the ship to be at sea and intended to use the sun, proceed as follows:

Set your watch to apparent time at ship, take from the azimuth tables the sun's true bearing for every four minutes of the time during which you will be occupied in the adjusting. Correct it into the correct magnetic bearing, and write it down plainly in a small pass book.

Ship's Head North.—Set the lubber's point of the pelorus at north, and the sight vanes clamped to the sun's magnetic bearing. Then starboard or port the helm until the sun's bearing is reflected and bisected by the thread of the pelorus vane. The vessel's head will now be north correct magnetic. If the compass agrees with the pelorus the compass is correct on that head. If the compass shows easterly deviation, place either before or abaft a steel magnet with its red end to starboard above or below in the most convenient place, but on the fore-and-aft center line of the compass. Reverse magnets for opposite deviation.

Ship's Head East.—Noting the apparent time ship and magnetic bearing of the sun, screw lubber's line of the pelorus east, and keep vanes set to sun's correct magnetic bearing. Port the helm until the sun is bisected in the sight vanes of the pelorus, steady her carefully on this fresh course. If the compass agrees with the pelorus it should show east; should it fail to do so, the difference is the deviation. If westerly deviation is shown, place a steel magnet fore and aftways on either side of the compass with its red end aft, and center on the athwartship line of the compass. Move it slowly towards the compass until half of the westerly deviation is corrected. Next place the Flinder's bar forward of the binnacle at such a distance as will cause the ship's head to appear due east, whence it may be securely bolted down to the deck. The semi-circular deviation of the compass is now corrected.

Quadrantal Deviation.—Put ship's head by the pelorus N. E. (Corr. Mgc.), noting apparent time as before. In nearly every case the deviation is easterly. Cast-iron cylinders or globes are placed on each side of the compass bowl and moved near to or further from it until the ship's head points N. E. by the compass also. This adjustment properly made does not require touching ever after unless some alterations are made in the ironwork near the compass or if the ship were to load a cargo of iron. **Rule.**—The ends of the correctors must not be nearer to the center of the card than $1\frac{1}{4}$ times the length of the longest needle. The compass is now fully adjusted, swing the ship for final deviation card.

Heeling Error.—This error is corrected by a vertical magnet placed under the center of the compass in a tube placed there to contain same. This error can best be corrected when vessel is rolling and is heading on or near a north or south course. North end of the needle is placed up in the northern hemisphere, and this is usually the position it retains. Observe the vibrations of the card which will be in excess of those made by the ship's actual motion, reduce same to normal by lowering or raising the magnet.

Semi-Circular Deviation is so termed because it has contrary names, thus if it is easterly on north, it is westerly on south.

Quadrantal Deviation is so termed because it is greatest on the four inter-cardinal points. It has the same name in opposite quadrants, thus, if it is easterly on N. E., it will be easterly on S. W. also, but westerly on S. E. and N. W. Thus the two kinds of deviation are vastly different.

Steel fore-and-aft magnets produce their greatest effect on east and west, diminishing to nothing on north and south when they become parallel to the compass needle.

Steel athwartship magnets produce their greatest effect on north and south, diminishing to nothing on east and west, when they become parallel to the compass needle.

Quadrantal correctors produce their greatest effect on N. E.; S. E.; S. W. and N. W.; tapering to nothing on N.; S.; E. and West.

A Flinder's bar placed on the center line of the compass before or abaft acts in the same way as the fore-and-aft steel magnets.

Course and Distance by Chart.—Mark a point upon the chart at the ship's position; then mark another point for which it is desired to steer; join the two by a line drawn with the parallel ruler, and, maintaining the direction of the line, move the ruler until its edge passes through the center of the compass rose and note the direction. If the compass rose indicates "true" directions, this will be the true course, and must be corrected for variation and deviation, applying west to the right, east to the left to obtain the compass course; if it is a "magnetic" rose, the course need be corrected for deviation only. The distance is measured on graduated meridian on the side of the chart on the middle latitude.

Before putting the ship on any course a careful look should be taken along the line over which it leads to be assured that it clears all dangers.

Cross Bearing.—Take a bearing of two fixed objects whose respective bearings from the ship differ, as nearly as possible, by 90°; taking one as quickly as possible after the other; correct the bearings for the deviation for the ship's head and the variation at the place, making the bearings true. Lay off the bearings on the chart from the objects used, and where the two lines cross one another will be the ship's position at time of taking the bearings.

Currents.—(See Tides and Currents.)

Danger Bearing.—If crossing a vessel or approaching the land observe a bearing. If this bearing does not change, risk of collision or grounding should be assumed.

Dead Freight.—Dead freight is when a charterer agrees to load a full cargo or a stated quantity and is unable to do so. Freight is claimed on the quantity he is short and should be paid before sailing.

Declination.—The angular distance of a heavenly body north or south of the celestial equator.

Demurrage.—Is a stated sum to be paid at the expiration of the lay day for every day detained. It is claimed day by day, and Saturday for Sunday.

Departure.—The amount of easting or westing made by a vessel in miles.

Deviation of the Compass.—Is the deflection of the compass needle from the magnetic meridian caused by the attraction of the hull, machinery, smokestacks, masts, or by certain elements of magnetism in the cargo. The manner of ascertaining the existence and amount of compass deviation is found by taking bearings of two fixed objects when in range; by equi-distant bearings; reciprocal bearings; or by azimuth and amplitude. Deviation is named east or west according as to the north point of the compass is drawn to the eastward or westward of the magnetic meridian.

Deviation of Compass by Distant Bearings.—The magnetic bearing of a fixed object may be obtained by taking a series of bearings on different compass headings, and taking the mean of the bearings as the magnetic bearing.

In choosing an object for use in this method care must be taken that it is at such a distance that its bearing from the ship does not practically differ as the vessel swings in azimuth. If the ship is swung at anchor, the distance should be not less than 6 miles. If swung under way, the object must be so far that the parallax (the tangent of which may be considered equal to half the diameter of swinging divided by the distance) shall not exceed 30′.

For Example: It is desired to find the deviation of the compass on the cardinal and inter-cardinal points of a ship having Ambrose Lightship distant 10 miles.

Ship's Head	Compass Bearing of Ambrose	Deviation
North	N 10° W	3° W
N E	N 11° W	2° W
East	N 13° W	0°
S E	N 12° W	1° W
South	N 13° W	0°
S W	N 14° W	1° E
West	N 15° W	2° E
N W	N 16° W	3° E

Sum of Compass Bearings $\frac{104°}{8}$ = N 13° W Magnetic Bearing.

As N 13° W is the magnetic bearing, therefore the difference between the compass bearing and the magnetic bearing is the deviation on that head, and we have the deviation as listed above.

Displacement.—It is the total amount of water displaced by a vessel afloat. It is equal to the weight of the ship itself and everything on board. Displacement varies according to the draft of the ship.

Diurnal Motion.—The term is commonly applied to the resultant apparent revolution of the heavens from east to west, the axis of which passes through the celestial poles, and is coincident in direction with the axis of the earth.

Dividers or Compasses.—This instrument consists of two legs movable about a joint, so that the points at the extremities of the legs may be set at any required distance from each other. It is used to take and transfer distances and to describe arcs and circles. When used for the former purpose it is termed "dividers," and the extremities of both legs are metal points; when used for describing arcs and circles, it is called a "compass," and one of the metal points is replaced by a pencil or pen.

Dot and Dash Code.—This method is used to converse with vessels at sea by means of flashlights, flags or whistle.

ALPHABET

A . –	N – .
B – . . .	O – – –
C – . – .	P . – – .
D – . .	Q – – . –
E .	R . – .
F . . – .	S . . .
G – – .	T –
H	U . . –
I . .	V . . . –
J . – – –	W . – –
K – . –	X – . . –
L . – . .	Y – . – –
M – –	Z – – . .

NUMERALS

1 . – – – –	6 – . . . .
2 . . – – –	7 – – . . .
3 . . . – –	8 – – – . .
4 . . . . –	9 – – – – .
5	0 – – – – –

ADDITIONAL SYMBOLS

Cornet – – – –	Code Interval or
Letters (follow) – – – .	Designator . – . –
Signals (follow) . . – –	

CONVENTIONAL SIGNALS

End of word	Interval
End of sentence	Double Interval
End of message	Triple Interval
Signal separating preamble from address; address from text; text from signature	– . . . –
Acknowledgment	. – . (R)
Error	. . . . .
Interrogatory	. . – – . .
Repeat after (word)	Interrogatory, A (word)
Repeat last word	Interrogatory twice
Repeat message	Interrogatory three times
Send faster	QRQ
Send slower	QRS
Cease sending	QRT
Wait a moment	. – . . .
Execute	IX, IX
Move to your right	MR
Move to your left	ML
Move up	MU
Move down	MD
Finished (end of work)	. . . – . –

Drag.—Take a heavy spar and lash a quantity of timbers to it with chains, and weight it well with kedge anchor. Attach a bridle, also a hawser, and lead hawser on board through hawse pipe, then launch it. The idea is that as this drag will float level with the sea and escape the wind, it will not drift as fast as the ship which stands high out of the water, and will tend to keep the vessel's head to the sea.

Ecliptic.—The plane of the ecliptic is that plane in or near which the center of gravity of the earth and moon revolves round the sun. The ecliptic itself is the great circle in which this plane meets the celestial sphere.

Equation of Time.—Is the difference between apparent time, determined by the meridian passage of the real sun, and mean time, determined by the passage of the mean sun.

The + sign indicates that the real sun reaches the meridian after mean noon; the – sign before mean noon.

Equinox.—The Equinoxes are those points at which the ecliptic and the equinoctial intersect, and when the sun occupies either of these positions the days and nights are of equal length throughout the earth. The Vernal Equinox is that one at which the sun appears to an observer on the earth when passing from southern to northern declination, and the Autumnal Equinox that one at which it appears when passing from northern to southern declination. The Vernal Equinox is also designated as the First Point of Aries, and is used as an origin of reckoning right ascension.

Establishment of Port.—Is the time of high water at full or new moon at a port, and can be determined by tide tables or coasting charts.

First Point of Aries.—That point in the heavens which the sun's center occupies when its declination changes from south to north; or when the sun crosses the line bound north.

Fogs and Fog Signals.—As with lights, the navigator should, in a fog, acquaint himself with the characteristics of the various sound signals which he is likely to pick up, and when one is heard, its periods should be timed and compared with those given in the light lists to insure its proper identity.

Experiment has demonstrated that sound is conveyed through the atmosphere in a very uncertain way; that its intensity is not always increased as its origin is approached, and that areas within its range at one time will seem silent at another. Add to these facts the possibility that, for some cause, the signal may not be working as it should be, and we have reason for observing the rule to proceed with the utmost caution when running near the land in fog.

The best guide is the lead, and that should be kept going constantly. The method of plotting soundings will give the most reliable position that is obtainable. Moreover, the lead will warn the navigator of the approach to shallow water, when, if his position is at all in doubt, it is wisest to anchor before it becomes too late.

When running slowly in a fog (which caution, as well as the law, requires that one should do) it must be borne in mind that the relative effect of current is increased; for instance, the angle of deflection from the course caused by a cross-set is greater at low than at high speed.

It is worth remembering that when in the vicinity of a bold bluff shore vessels are sometimes warned of a too close approach by having their own fog signals echoed back from the cliffs; indeed, from a knowledge of the velocity of sound it is possible to gain some rough idea of the distance in such a case.

Fog Whistle on Bow.—(Q) If you heard this, what would you do? (A) Stop the vessel, ascertain the position of the other vessel if possible, and then proceed with caution.

Four Point Bearing.—It is used to determine distance off an object when abeam. Take a bearing of the object when it bears four points on the bow and also when abeam. If the ship has held the same course while taking the two bearings the distance run between the two bearings will be the distance off the object when abeam.

Freeboard.—The height of upper deck at amidship above the waterline.

Gnomonic Chart.—This is based upon a system in which the plane of projection is tangent to the earth at some given point; the eye of the spectator is situated at the center of the sphere, where, being at once in the plane of every great circle, it will see all such circles projected as straight lines where the visual rays passing through them intersect the plane of projection. In a gnomonic chart, a straight line between any two points is projected as an arc of a great circle, and is therefore the shortest line between these points.

Excepting in the Polar regions, for which latitudes the Mercator projection can not be constructed, the gnomonic charts are not used for general navigating purposes. Their greatest application is to afford a ready means of finding the course and distance at any time in great circle sailing.

Great Circle.—The circle in which a sphere is cut by a plane is called a "great circle," when the cutting plane passes through the center of the sphere. Treating the earth as a sphere, the meridians of longitude are all great circles. Of the parallels of latitude, the equator only is a great circle. It is the most convenient method to sail by for the reason that the shortest line joining any two points is an arc of a great circle.

Greenwich Civil Time.—It consists of 24 hours. It commences at midnight and ends the next midnight, the hours being counted numerically from 0 to 24, so that the day begins and ends at midnight. All chronometers used by Americans and English are set to Greenwich civil time. To

convert watch or clock civil time into Greenwich civil time proceed as follows: If the civil time is A. M. take away the sign A. M. and keep same date, if P. M. add 12 to the hours, take away the sign P. M. and keep same date.

Gun.—*Instructions for the Use of the Gun and Rocket Apparatus as Practiced by the U. S. Life Saving Service.*—If your vessel is stranded and a shot with a small line is fired over it, get hold of the line, haul it on board until you get a tail block with an endless line rove through it, make the tail block fast to the lower mast well up, or in the event the masts have gone, to the best place to be found. Cast off small shot line, see that rope in block runs free, and make a signal to shore.

A hawser will be bent to the endless line on shore, and hauled off to your ship by the life-saving crew. Make hawser fast about two feet above the tail block, and unbend hawser from endless line. See that rope in block runs free, and make signals to shore.

Life savers on shore will then set hawser taut, and by means of the endless line haul off to your ship a breeches buoy.

Let one man get clear into the breeches buoy, thrusting his legs through the breeches, make signal to shore as before, and he will be hauled ashore by the life savers, and the empty buoy returned to the ship.

The following signals have been adopted by the Coast Guard of the U. S.:

1. Upon the discovery of a wreck by night the station crew will burn a red pyrotechnic light or a red rocket to signify, "You are seen; assistance will be given as soon as possible."

2. A red flag waved on shore by day, or a red light, red rocket, or red Roman candle displayed by night, will signify, "Haul away."

3. A white flag waved on shore by day, or a white light swung slowly back and forth, or a white rocket or white Roman candle fired by night, will signify "Slack away."

4. Two flags, a white and a red, waved at the same time on shore by day, or two lights, a white and a red, slowly swung at the same time, or a blue pyrotechnic light burned by night, will signify, "Do not attempt to land in your own boats; it is impossible."

5. A man on shore beckoning by day, or two torches burning near together by night, will signify, "This is the best place to land."

Gyro Compass.—This compass consists essentially of a rapidly spinning rotor, usually driven by a three-phase alternating current of electricity, at a rate varying according to the type, from 6,000 to 21,000 revolutions per minute, and so suspended that it automatically places its axis approximately in the direction of the geographical meridian and permits of the reading of the heading of the ship, unaffected by any magnetic influence, from a graduated compass card like that in use on magnetic compasses. From the "master compass," which may be located in a compartment below, electrical connections are made to "repeating compasses" on the bridge, in the conning tower, or in the steering-engine room, so that the ship's true heading may be transmitted to any desired part of the vessel.

The action of the gyro compass, affected as it is by the earth's rotation under it, conforms to Foucault's law that "a spinning body tends to swing around so as to place its axis parallel to the axis of any impressed forces, and so that its direction of rotation is the same as that of the impressed forces." Small corrections, depending upon the latitude, course, and speed, can be readily determined for application to the gyro compass readings either mechanically or by reference to tables.

Gyro-Pilot.—By being employed to actuate a contact maker, which would cause the rudder to respond instantly to slight variations of the vessel's head from the prescribed course, the gyro compass has lent itself to the production of the gyro pilot for mechanical steering, and likewise to the mechanical recording of the course pursued.

Hard Iron.—(Q) What are the properties of hard iron in acquiring and retaining magnetism? (A) It is less susceptible of being magnetised than soft iron, but when once magnetised it retains permanently a large part of the magnetism so received.

Heaving To.—(Q) How would you heave to in a gale under steam, or with engines disabled? (A) Slow the engines, head her up to the sea, and get on some after canvas. If she will not lay to, use a drag over the weather bow. If disabled try to make her lay her head to the sea with a drag over her bow, and some after canvas, but if she will not lay to, keep her helm amidship, take in the after canvas and pass the drag aft to the weather quarter and lay her stern to. If necessary use oil.

Heeling Error.—(See Compass Adjustment).

Hour Angle.—The angular distance of a heavenly body from the meridian, as measured around the celestial pole. It is equal to the angle at the pole between the hour circle through the body and the meridian, but is usually expressed in time.

Hurricanes.—(Q) How do you locate the center of tropical storms? (A) In the northern hemisphere look into wind and 8 points to the right will be the center approximately. In the southern hemisphere, 8 points to the left will be the approximate center.

Hurricanes.—(Q) How do you avoid the center of tropical storms?

(A) *Northern Hemisphere.*—Right or dangerous semi-circle, for steamers: Bring the wind on the starboard bow, make as much way as possible, and if obliged to heave to, do so head to sea. For sailing vessels: Keep close-hauled on the starboard tack, make as much way as possible, and if obliged to heave to, do so on the starboard tack.

Left or navigable semi-circle: For steam and sailing vessels: Bring the wind on the starboard quarter, note the course and hold it. If obliged to heave to, steamers may do so stern to sea; sailing vessels on port tack.

On the storm track in front of center; for steam and sailing vessels: Run for the left semi-circle with the wind on starboard quarter, and when in that semi-circle maneuver as above.

On the storm track in rear of center: Avoid it by the best practicable route, having due regard to the storm's recurving to the northward and eastward.

Southern Hemisphere: Left or dangerous semi-circle, for steamers: Bring the wind on the port bow, make as much way as possible, and if obliged to heave to, do so head to sea. For sailing vessels: Keep close-hauled on port tack, make as much way as possible, and if obliged to heave to, do so on the port tack.

Right or navigable semi-circle: For steam and sailing vessels: Bring the wind on the port quarter, note the course and hold it. If obliged to heave to, steamers may do so stern to sea; sailing vessels on starboard tack.

On the storm track in rear of center: Avoid it by the best practicable route, having due regard for the storm's recurving to the southward and eastward.

On the storm track in front of center: Steam and sailing vessels: Run for right semi-circle with the wind on port

quarter, and when in that semi-circle maneuver as above.

The above rules depend of course upon having sea room. In case land interferes, a vessel should heave to as recommended for the semi-circle in which she finds herself.

Hurricanes.—(Q) What motion has a hurricane? (A) Rotary and progressive. In the northern hemisphere they revolve left-handed or against the hands of a watch, in the southern hemisphere they revolve right-handed.

Hydrometer.—An instrument used for measuring the density or the specific gravity of liquids, used by seamen for finding the different drafts that a ship will float at, in fresh or salt water. The specific gravity of fresh water is 1000. The specific gravity of salt water is 1026. To find the draft a ship can be loaded to in fresh water, in order to ascertain the amount of water she will draw at sea, proceed as follows: Take the density of water at wharf, from below the surface if possible, by hydrometer. Multiply mean draft of ship by this reading, and divide by 1026. The result will be mean sea draft.

Example: Dock water reading of hydrometer 1006. Mean draft of vessel 21 feet.

$$\frac{1006 \times 21}{1026} = 20.6 \text{ ft. mean sea draft.}$$

International Code of Signals.—It consists of 26 flags (one for each letter of the alphabet), letters "A" and "B" are burgees, the remainder of the alphabet are square flags; 3 repeater pennants; 1 code flag or answering pennant; and 10 numeral pennants numbered from 1 to 0.

Two Flag Signals.—Are urgent and important signals. Such as "NC" which means "I am in distress."

Three Flag Signals.—Are general signals. Such as "CXL" which means "Do not abandon me."

Four Flag Signals.—Are geographical signals with letter "A" uppermost, and other signals explained in Volume II, International Code of Signals (Radiotelegraphy).

One Flag Signals.—

A	I am undergoing a speed trial.
B	I am taking in (or, discharging) explosives.
C	"Yes," or affirmative.
D	Keep clear of me—I am maneuvering with difficulty.
E	I am altering my course to starboard.

*F	I am disabled. Communicate with me.
G	I require a pilot.
H	I have a pilot on board.
I	I am altering my course to port.
J	I am going to send a message by semaphore.
*K	You should stop your vessel instantly.
*L	You should stop. I have something important to communicate.
M	I have a doctor on board.
N	"No," or negative.
*O	Man overboard.
*P	In Harbor (blue peter): I am about to proceed to sea. Hoisted on foremast. At Sea: Your lights are out, or burning badly.
Q	My vessel is healthy and I request a free pratique.
*R	The way is off my ship; you may feel your way past me.
S	My engines are going full speed astern.
T	Do not pass ahead of me.
*U	You are standing into danger.
*V	I require assistance.
*W	I require medical assistance.
X	Stop carrying out your intentions and watch for my signals.
Y	I am carrying mails.
*Z	To be used to address or call shore stations.

Only those marked with an asterisk should be used by flashing.

How to Make a Signal:

1. Ship A, wishing to make a signal, hoists her ensign, code flag under it.

2. When ship A has been answered by the vessel she is addressing she proceeds with the signal which she is to make, first hauling down her code flag if it is required for making the signal.

3. Each hoist should be kept flying until ship B hoists her answering pennant.

4. When ship A has finished signalling she hauls down her ensign.

How to Answer a Signal:

1. Ship B (the ship signalled to) on seeing the signal

made by ship A, hoists her answering pennant at the "Dip."

2. When A's signal has been taken in, looked out in the signal book, and is understood, B hoists her answering pennant "Close Up" and keeps it there until A hauls her hoist down.

3. B then lowers her answering pennant to the "Dip" and waits for next hoist.

4. If the flags in A's hoist cannot be made out, B keeps her answering pennant at the "Dip" and hoists the signal "OWL" or "WCX," or such other signal as may meet the case; and when A has repeated or rectified her signal, and B thoroughly understands it, B hoists her answering pennant "Close Up."

Invoice.—A bill of goods for stores or supplies or a claim against a vessel for unpaid bills, also a claim to hold cargo for freight unpaid.

Iron (See Hard Iron; Soft Iron).

Jury Rudder.—(Q) What method would you adopt to steer if rudder was disabled? (A) Rig a jury rudder as follows: Lash three derricks together in form of a triangle and board over the opening. Lash a kedge anchor to bottom corner to weight it down. Hold it in place with bridles to bollards on after deck. Make fast two stout wires to after end and lead one over each quarter to after winch and steer in that manner. Lash rudder securely to prevent further damage.

Latitude.—The angular distance of a place on the earth's surface north or south of the equator, expressed in degrees, minutes and seconds.

Law of Storms (See Hurricanes).

Lay-Days.—The number of days specified in the charter party for loading and discharging. They begin to count from the time of notice being given to the charterers of the vessel's readiness to load or discharge. Most charterers stipulate 24 hours after receipt of notice.

Lead Line.—To mark a lead line proceed as follows: At 2 fathoms, 2 strips of leather; 3 fathoms, 3 strips; 5 fathoms, white rag; 7 fathoms, red rag; 10 fathoms, a piece of leather with one hole; 13 fathoms, blue rag; 15 fathoms, white rag; 17 fathoms, red rag; 20 fathoms, piece of leather with 2 holes, or a piece of marline with two knots.

Leeway.—The drift of a vessel to leeward, or a falling behind or away from a set course.

Lights.—Before coming within range of a light the navigator should acquaint himself with its characteristics, so that when sighted it will be recognized. The charts, sailing directions, and light lists give information as to the color, character, and range of visibility of the various lights. Care should be taken to note all of these and compare them when the light is seen. If the light is of the flashing, revolving, or occulting variety the duration of its periods should be noted to identify it. If a fixed light, a method that may be employed to make sure that it is not a vessel's light is to descend several feet immediately after sighting it and observe if it disappears from view; a navigation light will usually do so, except in misty weather, while a vessel's light will not. The reason for this is that navigation lights are as a rule sufficiently powerful to be seen at the farthest point to which the ray can reach without being interrupted by the earth's curvature. They are therefore seen at the first moment that the ray reaches an observer on a ship's deck, and are cut off if he lowers the eye. A vessel's light, on the other hand, is usually limited by its intensity and does not carry beyond a distance within which it is visible at all heights.

Care must be taken to avoid being deceived on first sighting a light, as there are various errors into which the inexperienced may fall. The glare of a powerful light is often seen beyond the distance of visibility of its direct rays by the reflection downward from particles of mist in the air; the same mist may also cause a white light to have a distinctly reddish tinge, or it may obscure a light except within short distances. When a light is picked up at the extreme limit at which the height of the observer will permit, a fixed light may appear flashing, as it is seen when the ship is on the crest of a wave, and lost when in the hollow.

Many lights are made to show different colors in different sectors within their range, and by consulting his chart or books, the navigator may be guided by the color of the ray in which he finds himself; in such lights one color is generally used on bearings whence the approach is clear, and another covers areas where dangers are to be encountered.

The visibility of lights is usually stated for an assumed height of the observer's eye of 15 feet, and must be modified accordingly for any other height. But it should be

remembered that atmospheric and other conditions considerably affect the visibility, and it must not be positively assumed, on sighting a light, even in perfectly clear weather, that a vessel's distance is equal to the range of visibility; it may be either greater or less, as the path of a ray of light near the horizon receives extraordinary deflection under certain circumstances.

Log-Book.—Is a record of the ship's cruise, and, as such, an important accessory in the navigation. It should afford all the data from which the position of the ship is established by the method of dead reckoning; it should also comprise a record of meteorological observations.

Log; the Chip Log.—This instrument, for measuring the rate of sailing, consists of three parts: viz., the log-chip, the log-line, and the log-glass. A light substance thrown from the ship ceases to partake of the motion of the vessel as soon as it strikes the water, and will be left behind on the surface; after a certain interval, if the distance of the ship from this stationary object be measured, the approximate rate of sailing will be given. The log-chip is the float, the log-line is the measure of the distance, and the log-glass defines the interval of time.

The log-line is marked by the proportion 3600: 6080 feet = A : X

3600 = the number of seconds in an hour.
6080 = feet in a nautical mile.
A = the number of seconds the glass runs: 14; 28 or 30.
X = the number of feet and inches to measure off on the line to represent one knot.

To mark the line proceed as follows: Measure off 12 to 15 fathoms of stray line and put a piece of white rag to indicate the beginning of the marked line, and to know in heaving when to turn the time glass.

At 1 knot, a small strip of leather; 2 knots, 2 small strips of leather; 3 knots, a single knot; 4 knots, 2 knots; 5 knots, a single knot; 6 knots, 3 knots, and so on.

The Patent Log.—This is a mechanical contrivance for registering the distance actually run by a vessel through the water. There are various types of patent logs, but for the most part they act upon the same principle, consisting of a registering device, a fly or rotator, and a log or tow line.

Though not a perfect instrument, the patent log affords the most accurate means available for determining the vessel's speed through the water. It will usually be found that the indications of the log are in error by a constant percentage, and the amount of this error should be determined by careful experiment and applied to all readings.

Various causes may operate to produce inaccuracy of working in the patent log, such as the bending of the wings of the rotator by accidental blows, fouling of the rotator by seaweed or refuse from the ship, or mechanical wear of parts of the register. The length of the tow-line has much to do with the working of the log, and by varying the length the indications of the instrument may sometimes be adjusted when the percentage of error is small; it is particularly important that the line shall not be too short. The readings of the patent log cannot be depended upon for accuracy at low speeds, when the rotator does not tow horizontally, nor in a head or a following sea, when the effect depends upon the wave motion as well as upon the speed of vessel.

Longitude.—The distance of a place on the earth's surface east or west of some given prime meridian, expressed in degrees, minutes and seconds. The Americans and English use the prime meridian of Greenwich.

Longitude in Time.—The position or distance of a vessel east or west of some given prime meridian, expressed in hours, minutes and seconds.

Lowering a Boat.—(Q) What would you look after, and how would you place your men in the boat? (A) See if the plug was in the boat, and the davit falls all clear. Place one man in bow and another in stern to unhook davit tackles, rest of crew sitting down ready with oars.

Lubber's Line.—A vertical black line called the lubber's line is marked on the inner surface of the compass bowl, and the compass is so mounted that a line joining its pivot with the lubber's line is parallel to the keel line of the vessel; thus the lubber's line always indicates the compass direction of the ship's head.

Magnetic Bearing.—The direction pointed out by the magnetic meridian.

Magnetic Course.—The compass course corrected for the deviation.

Magnetic Equator.—Is a sinuous or wavy line north of the geographical equator from longitude 12° west, eastward

to longitude 170° west, the remainder being southward of the true equator. The greatest distance between the two equators is about 10° in the northern hemisphere, and 14° in the southern hemisphere.

Magnetic Poles.—The magnetic north pole is situated in latitude 70° north; longitude 97° west. The magnetic south pole in latitude 70° south; longitude 145° east.

Magnetic Storm.—Is a marked disturbance of the earth's magnetic conditions, lasting from a brief period to several days, and are due to sudden changes in the electric currents which circulate within the earth in the region surrounding the earth. They apparently are at random and may occur nearly simultaneously over the whole world or be restricted to a certain region. The range of effect upon the compass does not often exceed one degree.

Magnetism.—It may be described as a natural force which acts upon steel and iron in such a manner as to influence the working of the needles of any compass placed in their proximity.

Magnets.—It is a body having the polarity and the property characteristic of lodestone of strongly attracting iron and some other substances. Strictly speaking, a magnet is a piece of hardened steel charged with magnetism usually by artificial means.

Artificial magnets are made of steel with 3% of tungsten hardened by heating to a redness, then letting them cool quickly, drawing the temper by heat until they acquire a violent straw color, after which they are placed in a helix of insulated copper wire through which a powerful current of electricity is circulated. The above is the principal method, but with one magnet others can be made. A horse-shoe magnet is particularly convenient.

A magnet has two poles, the north end is marked red, the south end blue.

In stowing them away they should be placed with their opposite poles next to each other, for the reason that if the same poles were placed together their magnetic force would probably be reduced.

Manifest.—A list of the passengers, mail and cargo, with the names of the shippers and consignee, the name of the ship, master, port of loading and port of discharge. There are at least 3 copies made of it, one which is handed to the Custom boarding officers on the arrival at port of discharge, one for entering vessel at Custom House. Marks

and numbers of all packages must be also on the manifest.

Man Overboard.—(Q) What would be your duty? (A) Stop the ship, throw the stern of the ship from the man, send a man aloft to watch out and direct the boat, throw over a life buoy, and lower the lee boat.

Master.—(Q) On being appointed master of a steamer what are your duties? (A) Get a letter of appointment from the Owners or Agents, take it to the Custom House and have my name put on the ship's register. Inspect the vessel and equipment and see that all necessary repairs are made. See that certificate of inspection is in order, and the ship's articles properly filled out. Note that station bills, passenger certificates and officers' licenses are in order, framed and hung in a conspicuous place. Take an inventory of the stores and see that the vessel is fully equipped and has a full complement of officers and crew. Obtain all vouchers and accounts from the former master and if in a foreign port make an entry in the Official Log Book and both sign it. Interview the chief engineer, ascertain from him the quantity of fuel on board, the consumption per day and the average revolutions. Study the plans of the vessel and endeavor to make myself master of the situation.

Mate.—(Q) What are the duties of a Chief Mate? (A) See that vessel is fully stored for the intended voyage, deck repairs attended to, and life saving equipment in good condition. Before loading see that bilges are clean and dry, floors cleaned and proper dunnage laid. See that full complement of crew is on board and before leaving for sea examine anchors and see that they are ready for letting go at a moment's notice.

Mate.—(Q) What are the duties of a Second Mate? (A) Overhaul all the navigating gear, and see that a full set of charts is on board for the intended voyage; all flags of the international code in their proper places; a supply of blue lights and rockets, taff-rail log and deep sea sounding machine in good working order; hand lead properly marked; chronometers on board and rated; after mooring lines in good condition and any other duties that may be assigned by superior officers.

Mate.—(Q) What are the duties of a Third Mate? (A) When loading assist the chief mate in overlooking the proper stowage of the cargo in the forward end of the vessel, also attend to any other duty assigned me. When ready

for sea, see that telegraph is in good working order, quartermasters at their stations, and hand lead ready for immediate use.

Mate.—(Q) What is the duty of a mate on watch? (A) Keep a good lookout, watch the steering, see that man on lookout keeps a good lookout. If it comes on thick or foggy, stop or slow the vessel, blow the whistle, and send someone to call the master.

Mate.—(Q) What are the duties of a mate towards the master, passengers and crew? (A) The duty of an officer of a vessel is to obey all orders emanating from his superior officer; assist in the navigation of the vessel to the best of his ability; report to the master whenever the officer is of the opinion that a danger exists if the orders of his superiors are carried out; show an example to the crew by obeying all orders promptly; keep the passengers out of dangerous places; see that the crew know their stations in case of fire or collision; do not molest passengers; see that all life-saving and fire-fighting equipment is kept ready for use and in good condition; and keep a good lookout while on watch.

Mean Noon.—The time that the mean sun is supposed to cross the meridian of the observer.

Mean Sun.—An imaginary sun which is supposed to move uniformly, and to cross the same meridian at the same time every day, thus giving a value of exactly 24 hours to the day. This mean or fictitious sun sometimes crosses the observer's meridian a little in advance of the true sun, and other times a little after it, and this difference or interval between the real and imaginary suns is known as the equation of time.

Mean Time.—Is calculated by the motion of the mean sun. All watches and clocks represent mean time.

Mercator Chart.—It presents the earth to us as a flat surface, the meridians are parallel and equi-distant. The degrees of latitude are not equal—they increase in distance towards the poles in the same proportion as the degrees of longitude are diminished towards the poles on the globe. The figures represent the depth of the water in fathoms on the clear portions, in feet on the shaded portions, at a mean low water, and the letters the nature of bottom.

Mercator Sailing.—A method of finding the true course and distance between two places by employing meridional parts instead of the middle latitude.

Meridian.—The highest point reached by a heavenly body from its rising to its setting.

Meridian (180th).—If you crossed the 180th meridian bound West on Wednesday October 30, 1929, ship's time 12 P. M. of that date (or 0h 0m 0s Oct. 31); the Greenwich time would be 12h 0m 0s Oct. 31st; and after crossing it would be necessary to add 12 hours to Greenwich time to find local time, for the reason that the ship is now in East longitude; and consequently the ship's time must be greater than the Greenwich time, which would make the ship's time 12 P. M. Oct. 31st (or 0h 0m 0s Nov. 1st); and therefore Oct 31st has been lost.

In sailing East and crossing the 180th meridian at 12 P. M. Oct. 30th at ship (or Oct. 31st 0h 0m 0s) local time; the Greenwich time would be 12h 0m 0s Oct. 30th; and after crossing it would be necessary to subtract 12 hours from the Greenwich time to find local time, for the reason that the ship is now in West longitude, and the ship's time must be less than the Greenwich time, which would make the ship's time 12 P. M. of Oct. 29th (or 0h 0m 0s Oct. 30th). Therefore we have two days of the same date Oct. 30th.

Meridian Altitude.—(See Altitude.)

Middle Latitude Sailing.—The method of finding the true course and distance between two places by employing the middle latitude between them.

Nadir.—Opposite to zenith. A term used in astronomy for the point in the heavens exactly opposite the zenith, the zenith and nadir being the two poles of the horizon.

Parallax.—Is the correction applied to apparent altitude of sun; caused by observing the sun from the earth's surface instead of its center.

Parallel Rulers.—Are used for drawing lines parallel to each other in any direction, and are particularly useful in transferring the rhumb-line on the chart to the nearest compass-rose to ascertain the course, or to lay off bearings and courses.

Parallel Sailing.—Sailing on a parallel; sailing true east or west.

Pelorus.—An instrument used for observing bearings and for finding the deviation of the compass. It is a dummy compass, with sight vanes attached.

Plane.—A surface such that a straight line joining any two of its points lies wholly within the surface.

Polar Distance.—The angular distance of a heavenly body from the pole nearest the observer.

Polyconic Chart.—The meridians converge toward the poles and are curved lines, the degrees of latitude and longitude are projected according to their true value. A straight line represents a near approach to a great circle and cuts all the meridians at a slightly different angle.

Position by One Bearing.—(Q) How would you find the approximate position of a vessel by taking one bearing of a point or light? (A) Take a bearing of the point, and drop the lead. Then go to the chart and draw a line representing the bearing of the particular point, and hunt along this line until the depth of water and nature of bottom is found. The result will be the approximate position of the vessel.

Prime Vertical.—A heavenly body is on the prime vertical when it bears true east or west. In this position it is the best time to make an observation for longitude, as an error in latitude will have no effect on the longitude.

Protractor.—An instrument used for the measurement of angles upon paper.

Protest.—On arrival of ship the master should note a protest against wind and weather and that he expects damage to his ship and cargo. After entering ship at custom house, if in a home port go to a notary public, if in a foreign port to the American Consul. There are regular forms for noting protest, and it should be made in 24 hours after arrival. The time limit for extension is six months.

The documents necessary are the ship's log, kept and written daily by the chief officer, and signed by himself and master. It should state the conditions of wind and weather, accidents, damage, latitude and longitude, and the time of occurrence.

The ship's responsibility of damage is cleared if the cargo is properly dunnaged and stowed.

Quadrant.—The quadrant is properly an octant, as the limb is only the eighth part of a circle, or 45°; but, like the sextant, being an instrument of double reflection, it is divided into 90°.

Both instruments are constructed on the same principle and can be made equally accurate and perfect. (See Sextant.)

Radius.—A straight line from the center of a circle or sphere to its side.

Reciprocal Bearings.—To obtain deviation by reciprocal bearings a compass is taken on shore and placed where it is free from magnetic disturbance. When ship's head is steadied on a certain course a bearing is taken of the shore compass at the same instant that those on shore take a bearing of the ship's compass, after, ship is swung and bearings taken on all points in this manner. All bearings taken by the shore compass, which are magnetic, must be reversed, and the difference between these bearings and the bearings taken by the ship's compass will be the deviation for the ship's head on the respective compass points.

Refraction.—The change of direction of a ray of light in passing through atmospheric mediums of varying density.

Respondentia.—A contract whereby the cargo is pledged in security of money advanced for the purpose of the voyage.

Rhumb-Line.—A line or course crossing successive meridians at the same angle.

Right Ascension.—The distance in time of a heavenly body reckoned eastward on the equinoctial from the First Point of Aries.

Semaphore Code.—The two-arm semaphore system is shown in the following table. All semaphore signals are spelled-out messages unless preceded by "signals."

With the machine, "interval" is made by closing the arms but leaving the indicator showing. "Double interval" is two successive chop-chop signals. "Triple interval" is three successive chop-chop signals, followed by the closing of both arms and indicator. The chop-chop signal is made by placing both arms at the right horizontal and then moving them up and down in a cutting motion, the indicator being displayed. With hand flags, "interval" is as shown in the table; "double interval" is two successive chop-chop signals; "triple interval" is three successive chop-chop signals and withdrawing the flags from view.

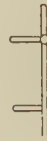
Conventional signals are used with the following exceptions:

Error	"A" (chopped)
Interrogatory	"O" (chopped)

Those of five or six elements cannot be made out and must be spelled out.

Semi-Diameter.—Half a diameter; or the distance from the top or bottom of the sun to its center.

THE SEMAPHORE SYSTEM.

CHARACTERS	TWO-ARM SEMAPHORE			CHARACTERS	TWO-ARM SEMAPHORE		
	MACHINE	HAND FLAGS	SECONDARY MEANINGS		MACHINE	HAND FLAGS	SECONDARY MEANINGS
A			Error.	I			
B				J			
C				K			Negative.
D				L			Preparatory.
E				M			
F				N			Annulling.
G				O			Interrogatory.
H				P			Affirmative.

THE SEMAPHORE SYSTEM.

CHARACTERS	TWO-ARM SEMAPHORE			CHARACTERS	TWO-ARM SEMAPHORE		
	MACHINE	HAND FLAGS	SECONDARY MEANINGS		MACHINE	HAND FLAGS	SECONDARY MEANINGS
Q				X			
R			Acknowledge.	Y			
S				Z			
T				Cornet.			
U				Letters (follow).			
V				Signals (follow).			
W				Interval.			Designator.

Sextant.—An instrument of reflection used by navigators for measuring the altitudes of heavenly bodies. It derives its name from the extent of its limb, which is the sixth part of a circle, or 60°; but being an instrument of double reflection it is divided into 120°.

Sextant Adjustments—First Adjustment.—The index glass must be perpendicular to the plane of the instrument. To do this, place the vernier about the middle of the arc, look into the index glass and see if the true and reflected arcs appear in a straight line in the index glass. If they do, the index glass is perpendicular to the plane of the instrument; if not, it is to be made so by handling the screws at the back of the index glass.

Second Adjustment.—The horizon glass must be perpendicular to the plane of the instrument. To do this, place the vernier on zero, hold the instrument face up and obliquely, look through telescope ring into horizon glass and see if the true and reflected horizons appear in an unbroken line in the horizon glass. If they do, the horizon glass is perpendicular to the plane of the instrument. If they do not, they are to be made to appear so by handling the upper screw at the back of the horizon glass.

Third Adjustment.—The horizon glass must be parallel to the index glass when the vernier is set on zero. To do this, clamp the vernier on zero, hold the instrument vertically and obliquely, look through telescope ring into horizon glass, and see if the true and reflected horizons appear in an unbroken line in the horizon glass. If they do, the horizon glass is parallel to the index glass, if they do not, they are to be made to appear so by handling the lower screw at the back of the horizon glass.

If the lower screw at the back of the horizon glass is lost or broken it would be impossible to make the horizon glass parallel to the index glass, so make the index glass parallel to the horizon glass by moving the tangent screw until the true and reflected horizons show in an unbroken line in the horizon glass. The result would be an index error, to be subtracted from the observed altitude if the reading is on the arc, to be added if reading is off the arc.

To know if an instrument is free of error or not, move the arrow of the vernier slightly off the zero of the arc, hold the instrument as if taking an observation, and by the tangent screw bring the true and reflected horizons into an unbroken line in the horizon glass. If then the

arrow is on zero, the instrument is free of error, if not, there will be an index error to be applied to each observed altitude as explained before.

Fourth Adjustment.—Is to set the axis of the telescope parallel to the plane of the instrument. To do this, screw in the inverting telescope, taking care that one pair of wires is parallel to the plane of the instrument. Select two celestial objects, not less than 90° apart (two bright stars answer the purpose best), bring the first star close to the second by moving the vernier along the arc, then by the tangent screw bring them in contact on the inner wire and by a slight movement of the wrist throw them over to the outer wire. If they remain in contact, the telescope is parallel to the plane of the instrument; if they do not, the adjustment is made by the screws in the telescope collar.

To find the index error by measuring the sun's diameter, proceed as follows:

Move the vernier about 30 minutes off the arc, look direct at the sun through the telescope. By the tangent screw bring the limbs of the true and reflected suns into exact contact, note the reading and mark it "*off.*" Again move the vernier about 30 minutes on the arc, proceed as above, note the reading and mark it "*on.*" Subtract lesser from greater reading and divide by 2. This will be the index error taking the name of the greater reading, plus or minus.

To prove the measurement has been taken accurately add the two readings together and divide the sum by 4. The result will be nearly equal to the semi-diameter given in the nautical almanac for that day.

The fourth adjustment is never made on a quadrant.

Shackles.—(See Chain Shackles.)

Ship Ashore.—(Q) Your ship is ashore, your boats and liferafts are all stove in, what would you do to save the people on board your vessel? (A) Send up distress rockets and make distress signals to attract the attention of the life-saving crew on shore. If not answered, build a raft out of anything that will float, bend a line to it, and throw the raft overboard and see if it will drift ashore. If so, haul it back again and put two good swimmers and a long line on the raft, and then let it drift as near the shore as it will go, then let the men jump over and swim ashore with the line. Then haul the raft backward and forward until every one is off the vessel.

Siderial Time.—Is measured by the stars. Siderial time commences when the First Point of Aries is on the meridian, and is counted from 1 to 24 hours, when the same point returns to the meridian again.

Sinking Vessel.—(Q) How would you approach a sinking vessel with a boat in a heavy sea and take the people off, if it were too rough to go alongside? (A) Run dead to windward of the sinking vessel as close as safety will permit; stop my ship and make one side of my ship a lee side, lower away the lee boat, and at the same time throw overboard a can of oil to smooth the sea. Let the boat drift down toward the wreck, and when the boat is near the wreck, look out for wreckage and fall in on the lee side of the wreck as near as possible. If dangerous to go alongside, throw the boat head up and let a man stand in the bow of the boat and throw a heaving line with a bowline in the end of it on board the wreck. One of the people on board will place the line around him, and then jump overboard, and be hauled into the boat. The vessel in the meantime will run to the leeward and wait for the boat, when she leaves the wreck with a boat load of people. This will be repeated until everybody is off the wreck.

Soft Iron.—Is instantly magnetised when exposed to any magnetic force, but has no power of retaining it.

Solar Time.—Is time measured by the sun.

Sounding Machine.—The deep-sea sounding machine has a reel of fine wire to which the lead is attached by a line having made fast to it the lead and a brass tube. Into the brass tube is placed the depth recorder, which is a long glass tube, which is placed sealed end up. When the lead is armed and everything is ready the brake is released, and the wire is allowed to run out until the bottom is struck. The amount of wire run out is shown by an indicator on the side of the machine. The amount of wire is not the depth of water obtained, as the amount run out varies with the speed of the ship. The wire is then reeled back, and the glass tube is taken out. The pressure of the water causes the tube to become discolored a certain length up for a certain depth, and the amount of such depth is found by measuring the discoloration on a scale provided for that purpose.

Soundings.—The practice should be followed of employing a leadsman to take and report soundings continuously while in shoal water or in the vicinity of dangers. The

soundings must not be regarded as fixing a position, but they afford a check upon the positions obtained by other methods. An exact agreement with the soundings on the chart need not be expected, as there may be some little inaccuracies in reporting the depth on a ship moving with speed through the water, or the tide may cause a discrepancy, or the chart itself may lack perfection; but the soundings should agree in a general way, and a marked departure from the characteristic bottom shown on the chart should lead the navigator to verify his position and proceed with caution; especially is this true if the water is more shoal than expected.

Specific Gravity.—(See Hydrometer.)

State of Sea.—The state of the sea is expressed by the following system of symbols:

B. Broken or irregular sea.
C. Chopping, short, or cross sea.
G. Ground swell.
H. Heavy Sea.
L. Long rolling sea.
M. Moderate sea or swell.
R. Rough sea.
S. Smooth sea.
T. Tide-rips.

Station Bill.—Method of preparing a station bill for fire and boat drill on an ocean passenger steamer. Steamers' crew consists of the following members:

One master; 4 mates; 1 boatswain; 2 carpenters; 3 quartermasters; 12 seamen; 1 chief engineer; 3 assistant engineers; 3 junior engineers; 6 oilers; 3 water tenders; 18 firemen; 9 coal passers; 1 deck engineer; 1 steward; 1 assistant steward; 4 cooks; 1 baker; 3 messmen; 2 pantrymen; 12 waiters; 2 wireless operators and 1 purser.

Vessel has 12 lifeboats allowed 36 persons each. 12 fire plugs and 2 hand pumps.

FIRE DRILL

Rapid Ringing of Ship's Bell.—All crew to report to their proper fire stations, connect hose and have same ready to be run in direction as ordered.

Master in general charge on bridge, with 1 quartermaster as aid. Quartermaster on watch at the wheel.

First Officer in charge of deck, and to see that orders of master are obeyed.

Chief Engineer in charge of his department.

Third assistant engineer to take charge of engine room and fire pumps, with his watch consisting of 1 junior

engineer, 2 oilers, 1 water tender, 6 firemen and 3 coal passers. Fire pumps to be started and stopped when directed from bridge.

Hydrant No. 1
Third Officer (in charge)
Water Tender No. 1
Fireman No. 1
Coal Passer No. 1

Hydrant No. 2
Fourth Officer (in charge)
Seaman No. 1
Fireman No. 2
Coal Passer No. 2

Hydrant No. 3
Boatswain (in charge)
Seaman No. 2
Fireman No. 3
Coal Passer No. 3

Hydrant No. 4
First Engineer (in charge)
Seaman No. 3
Fireman No. 4
Coal Passer No. 4

Hydrant No. 5
Second Engineer (in charge)
Seaman No. 4
Fireman No. 5
Officers' Messman

Hydrant No. 6
Junior Engineer (in charge)
Seaman No. 5
Fireman No. 6
Firemen's Messman

Forward Hand Pump
Quartermaster (in charge)
Seaman No. 11
Coal Passer No. 5
Fourth Cook

Hydrant No. 7
Junior Engineer (in charge)
Seaman No. 6
Fireman No. 7
Sailors' Messman

Hydrant No. 8
Oiler No. 1 (in charge)
Seaman No. 7
Fireman No. 8
First Pantryman

Hydrant No. 9
Oiler No. 2 (in charge)
Seaman No. 8
Fireman No. 9
Second Pantryman

Hydrant No. 10
Oiler No. 3 (in charge)
Seaman No. 9
Fireman No. 10
Chief Cook

Hydrant No. 11
Oiler No. 4 (in charge)
Seaman No. 10
Fireman No. 11
Second Cook

Hydrant No. 12
Second Officer (in charge)
Water Tender No. 2
Fireman No. 12
Third Cook

After Hand Pump
Deck Engineer (in charge)
Seaman No. 12
Coal Passer No. 6
Baker

Chief carpenter in charge of fire axes forward with 1 waiter as assistant.

Second carpenter in charge of fire axes aft with waiter No. 2 as assistant.

Purser, steward, assistant steward and 10 waiters to take charge of fire buckets and fire extinguishers, and to take charge of and assure passengers.

Two wireless operators on watch in radio room.

BOAT DRILL AND ABANDON SHIP

Several Short Blasts of Steam Whistle.—All boat crews to report to their station, uncover and swing out boats.

Officer in charge of each boat to see that his proper complement of crew and passengers report, and that plug is in boat, falls clear, and ready for lowering.

Boats shall be loaded quietly without unnecessary excitement and overcrowding.

Lifeboats of this class are required to have at least 2 certificated lifeboat men, and officer in charge shall see that the proper men are put in charge of handling the falls for lowering the boat.

Notices shall be posted in every passenger stateroom of the number of the boat the passenger is to report to, in case of boat drill or to abandon ship.

Every passenger shall be required immediately after leaving port to participate in a boat drill, and also instructed in the proper way to adjust a cork life preserver.

No boat shall be lowered until ordered by master or a proper representative of him.

STATION BILL FOR BOAT DRILL

No. 1 Boat (Starboard Side)	No. 2 Boat (Port Side)
Master (in charge)	Chief Officer (in charge)
Seaman No. 1 (Cer. Lifeboat Man)	Seaman No. 2 (Cer. Lifeboat Man)
Fireman No. 1 (Cer. Lifeboat Man)	Fireman No. 3 (Cer. Lifeboat Man)
Chief Steward	First Asst. Engineer
Oiler No. 1	Water Tender No. 1
Coal Passer No. 1	Fireman No. 3
Chief Cook	Baker
Wireless Operator	Wireless Operator

No. 3 Boat
(Starboard Side)

Second Officer (in charge)
Seaman No. 3 (Cer. Lifeboat Man)
Fireman No. 4 (Cer. Lifeboat Man)
Second Asst. Engineer
Water Tender No. 2
Fireman No. 6
Officers' Messman
Waiter No. 1

No. 6 Boat
(Port Side)

Chief Carpenter (in charge)
Seaman No. 6 (Cer. Lifeboat Man)
Fireman No. 9 (Cer. Lifeboat Man)
Junior Engineer
Coal Passer No. 3
Fireman No. 11
Chief Pantryman
Waiter No. 4

No. 4 Boat (Port Side)

Third Officer (in charge)
Seaman No. 4 (Cer. Lifeboat Man)
Fireman No. 5 (Cer. Lifeboat Man)
Third Asst. Engineer
Water Tender No. 3
Fireman No. 7
Firemen's Messman
Waiter No. 2

No. 7 Boat
(Starboard Side)

Second Carpenter (in charge)
Seaman No. 7 (Cer. Lifeboat Man)
Fireman No. 12 (Cer. Lifeboat Man)
Junior Engineer
Coal Passer No. 4
Fireman No. 14
Second Pantryman
Waiter No. 6

No. 5 Boat
(Starboard Side)

Fourth Officer (in charge)
Seaman No. 5 (Cer. Lifeboat Man)
Fireman No. 8 (Cer. Lifeboat Man)
Junior Engineer
Coal Passer No. 2
Fireman No. 10
Sailor's Messman
Waiter No. 3

No. 8 Boat
(Port Side)

Boatswain (in charge)
Seaman No. 8 (Cer. Lifeboat Man)
Fireman No. 13 (Cer. Lifeboat Man)
Oiler No. 2
Coal Passer No. 5
Deck Engineer
Waiter No. 5
Waiter No. 7

No. 9 Boat
(Starboard Side)

Chief Engineer (in charge)
Seaman No. 9 (Cer. Lifeboat Man)
Fireman No. 15 (Cer. Lifeboat Man)
Oiler No. 3
Coal Passer No. 6
Assistant Steward
Waiter No. 8
Waiter No. 9

No. 11 Boat
(Starboard Side)

Quartermaster No. 2 (in charge)
Seaman No. 11 (Cer. Lifeboat Man)
Fireman No. 17 (Cer. Lifeboat Man)
Oiler No. 5
Coal Passer No. 8
Third Cook
Waiter No. 11

No. 10 Boat
(Port Side)

Quartermaster No. 1 (in charge)
Seaman No. 10 (Cer. Lifeboat Man)
Fireman No. 16 (Cer. Lifeboat Man)
Oiler No. 4
Coal Passer No. 7
Purser
Second Cook
Waiter No. 10

No. 12 Boat
(Port Side)

Quartermaster No. 3 (in charge)
Seaman No. 12 (Cer. Lifeboat Man)
Fireman No. 18 (Cer. Lifeboat Man)
Oiler No. 6
Coal Passer No. 9
Fourth Cook
Waiter No. 12

Storm Laws.—(See Hurricanes).

Storm Signals.—U. S. Weather Bureau Signals.

The Small Craft Warning.—A red pennant displayed alone indicates that, while the wind may not reach a velocity sufficiently high to justify the display of a regular storm warning, it will interfere with the safe operation of small craft, such as those engaged in fishing, towing, motor-boating, and yachting.

The Storm Warning.—A red flag (8 ft. square) with black center (3 ft. square) indicates that a storm of marked violence is expected.

Pennants.—The pennants displayed with the flag indicate the direction from which the wind is expected to blow.

The Red Pennant (8 ft. hoist and 15 ft. fly) displayed with the flag indicates easterly winds.

The White Pennant (8 ft. hoist and 15 ft. fly) displayed with the flag indicates westerly winds.

When the red pennant is hoisted above the storm flag winds are expected from the Northeast quadrant; when below, from the Southeast quadrant.

When the white pennant is hoisted above the storm flag, winds are expected from the Northwest quadrant; when below, from the Southwest quadrant.

Night Warnings.—By night, two red lights one above the other indicate winds from the Northeast quadrant; a single red light indicates Southeast quadrant; a white light above a red light indicates Northwest quadrant; and a red light above a white light indicates Southwest quadrant.

The Hurricane Warning.—Two storm flags (red with black center) displayed one above the other, are used to announce the expected approach of tropical hurricanes, and also those extremely severe and dangerous storms which occasionally move across the Lakes and northern Atlantic Coast.

The Night Hurricane Warning.—Two red lights with a white light between in a vertical line.

Stowage of Cargo.—When the cargo is discharged from the ship all the holds and 'tween decks should be well cleaned and dunnage stacked up on the side ready for next cargo.

Dunnage is loose wood, laid on the bottom and 'tween deck of a vessel to prevent damage by vessel leaking, leaking water pipes, liquid cargo leaking, etc.

Dunnage should be laid in the holds fore and aft about 9 inches high, and in the 'tween deck athwartship about 3 inches high. The reason for laying dunnage in this way is to allow any water that may get under the cargo to have free access to bilge suctions and scupper pipes.

Casks are stowed fore and aft, bung up, and bilge free, with dunnage under the quarters, and well chocked off. Begin amidship for first tier, and work toward the wings.

To determine the location of the bung of a cask, if it is not visible, look for the rivets in the hoops, which will always be in line with the bung.

Bale goods should be stowed on their flat, with marks and numbers up.

Acids should be stowed on deck, so that they can readily be thrown overboard in case of leakage, and should be securely lashed.

Tar, oil, rosin, etc., should be stowed underneath dry and perishable cargo which it would damage by leakage if stowed on top.

Wines should be stowed in a place not accessible to the crew, which can be locked to prevent pilfering.

When carrying a cargo of cotton special attention should be given that dunnage is well laid, and all iron work in holds properly protected, so that no friction may occur between the bands of the bales and the iron work.

A cargo of coal should be taken on board dry, and plenty of surface ventilation given to holds to avoid against the coals getting heated and taking fire. In fine weather at sea the hatches should be left open, and the temperature of the holds taken each watch. In case of fire batten down all hatches, ventilators, etc., and turn steam in holds; it is possible in some instances to hold the fire in this way.

On taking on board a cargo of steel rails operations should begin in the main hold, and the iron stowed fore and aft until level with keelson, then stowed grating fashion. To protect the sides of the vessel, place rails fore and aft and also have locking tiers of rails; when high enough lash all together with chains, and place battens across and tome all down securely from beams; also tome from the sides of the vessel.

A cargo of iron should be stowed in the body of the vessel, trimmed towards the wings, and raised up in the holds to a good height; by doing so the vessel will be in better trim for rough weather, and will not roll so heavily.

For general cargo have all the holds cleaned and dunnage laid down. Consider the nature of cargo, and stow it in the various holds so that the vessel will be kept in good trim. The quantity of coal in the bunkers will have to be taken into consideration. If the vessel is to call at a number of ports, the cargo should be stowed so that at the first port of call the cargo for that place will be handy for discharging.

Deadweight should be stowed in the lower holds, and used for trimming the ship; bale goods, etc., on top; tallow and butter should be kept in a cool place away from fireroom bulkhead; liquors should be kept in a locker in the 'tween deck for that purpose.

A cargo of iron ore takes up little space in a vessel, as the ship is down to her draught before the holds are full. This cargo of deadweight should be placed in the body of

the vessel, raised up in the main hold, and trimmed out towards the wings, also fore and aft to keep vessel in trim. By stowing cargo high up the vessel will behave better in a seaway.

To carry a cargo of grain in bulk, have all holds cleaned out and bilges clear. The holds must be divided into compartments by means of fore-and-aft shifting boards 3 inches thick and athwartship bulkheads, the various compartments being grain-tight and strongly constructed from the bottom of the hold right up to the deck. The 'tween deck must be fitted with feeders to feed the lower hold.

When the grain is coming on board it ought to be well trimmed into all the corners and tramped down, otherwise if the vessel encounters bad weather, she will probably take a heavy list by the cargo settling over to the lee side. All grain cargoes must be properly trimmed, stowed and secured.

If the vessel is not fitted up with properly constructed feeders, she must have not less than one-fourth of the grain carried in each hold or compartment made up in bags, and before shipping the bags, matting and platforms must be laid upon the grain in bulk.

Weights should be distributed when loading, about two-thirds in lower holds and one-third in 'tween deck approximately.

Deck cargo should be well secured, and particular attention given to cargo stowed on after deck to keep it clear from steering chains or rods.

A practical rule for ascertaining strength of rope is given below:

Square the circumference and divide by 3 for breaking strain in tons, by 6 for working strain.

To find the weight rope will lift, when rove as a tackle:

Multiply the weight the rope is capable of lifting, by the number of parts at the moving block, and less one quarter for resistance.

To find the number of parts of small rope required to equal a larger rope:

Divide the square of the circumference of the larger rope by the square of the circumference of the smaller, result will be number of parts the smaller rope requires.

Terrestrial Magnetism.—Is a magnetic force which pervades the whole earth and from whence the magnetic properties of every particle of iron entering the ship's construction is derived.

Thermometer.—Is an instrument for indicating temperature. In its construction advantage is taken of the fact that bodies are expanded by heat and contracted by cold. In its most usual form the thermometer consists of a bulb filled with mercury, connected with a tube of very fine cross-sectional area, the liquid column rising or falling in the tube according to the volume of the mercury due to the actual degree of heat, and the height of the mercury indicating upon a scale the temperature; the mercury contained in the tube moves in a vacuum produced by the expulsion of the air through boiling the mercury and then closing the top of the tube by means of the blowpipe.

There are three classes of thermometer, distinguished according to the method of graduating the scale as follows: The Fahrenheit, in which the freezing point of water is placed at 32° and its boiling point (under normal atmospheric pressure) at 212°; the Centigrade, in which the freezing point is at 0° and the boiling point at 100°; and the Réaumur, in which these points are at 0° and 80°, respectively. The Fahrenheit thermometer is generally used in the United States and England.

The thermometer is a valuable instrument for the mariner, not only by reason of the aid it affords him in judging meteorological conditions from the temperature of the air and the amount of moisture it contains, but also for the evidences it furnishes at times, through the temperature of the sea water, of the ship's position and the probable current that is being encountered.

Tides and Currents.—The information relating to the tides given on the chart and in other publications should be studied, as it is of importance for the navigator to know not only the height of the tide above the plane of reference of the chart, but also the direction and force of the tidal current.

The plane of reference adopted for soundings varies with different charts; on a large number it is that of mean low water, and as no plane of reference above that of mean low water is ever employed, the navigator may with safety refer his soundings to that level when in doubt.

When traversing waters in which the depth exceeds the vessel's draft by but a small margin, account must be taken of the fact that strong winds or a high barometer may cause the water to fall below even a very low plane of reference. On coasts where there is much diurnal inequality in the

tides, the amount of rise and fall cannot be depended upon, and additional caution is necessary.

A careful distinction should be made between the vertical rise and fall of the tide, which is marked at the transition periods by a stationary height, or stand, and the tidal current, which is the horizontal transfer of water as a result of the difference of level, producing the flood and ebb, and the intermediate condition, or slack. It seldom occurs that the turn of the tidal stream is exactly coincident with the high and low water, and in some channels the current may outlast the vertical movement which produces it by as much as three hours, the effect being that when the water is at a stand the tidal stream is at its maximum, and when the current is slack the rise or fall is going on with its greatest rapidity. Care must be taken to avoid confounding the two. Usually, more complete data are furnished in charts and tide tables regarding the rise and fall, and it frequently occurs that the information regarding the tidal current is comparatively meager; the mariner must therefore take every means to ascertain for himself the direction and force of the tidal and other currents, either from the set shown between successive well-located positions of the ship, or by noting the ripple of the water around buoys, islets, or shoals, the direction in which vessels at anchor are riding, and the various other visible effects of the current.

Current arrows on the chart must not be regarded as indicating absolutely the conditions that are to be encountered. They represent the mean of the direction and force observed, but the observations upon which they are based may not be complete, or there may be reasons that bring about a departure from the normal state.

Generally speaking, the rise and fall and strength of current are at their minimum along straight stretches of coast upon the open ocean, while bays, bights, inlets, and large rivers operate to augment the tidal effects, and it is in the vicinity of these that one finds the highest tides and strongest currents. The navigator need therefore not be surprised, in cruising along a coast, to notice that his vessel is set more strongly toward or from the shore in passing an indentation, and that the evidences of tide will appear more marked as he nears its mouth.

Tonnage.—"Gross" Tonnage is the entire internal capacity or volume of a ship measured according to certain

rules specified in the navigation laws of the United States and according to size and type of vessel.

"Net" Tonnage is supposed to represent the earning capacity of the ship, and it is therefore made the basis for port and navigation charges, it being calculated by deducting from the gross tonnage allowances for crew quarters, engine and boiler room, shaft alley, etc.

In every vessel documented as a vessel of the United States the number denoting her net tonnage shall be deeply carved or otherwise permanently marked on her main beam, and shall be so continued; and if the number at any time cease to be continued such vessel shall be subject to a fine of $30 on every arrival in a port of the United States if she have not her tonnage number legally carved or permanently marked.

True Altitude.—(See Altitude).

True Course.—Is the compass course corrected for deviation and variation.

Ullage.—The measure from the top of a tank to the top of the oil cargo, or the empty space in the tank.

Variation of the Compass.—The compass needle when uninfluenced by deviation points to the magnetic poles of the earth, and as these do not coincide with the true or geographical poles, the magnetic meridians form an angle with the true meridians, and this is called the variation of the compass, which varies in extent in different parts of the world. The variation of the compass is not constant, but undergoes an annual change, and the amount of this yearly increase or decrease will be found plainly marked on charts.

Weather.—To designate the weather a series of symbols devised by the late Admiral Beaufort is employed The system is as follows:

b. Clear blue sky.
c. Clouds.
d. Drizzling, or light rain.
f. Fog, or foggy weather.
g. Gloomy, or dark, stormy weather.
h. Hail.
l. Lightning.
m. Misty weather.
o. Overcast.
p. Passing showers of rain.
q. Squally weather.
r. Rainy weather, or continuous rain.
s. Snow, or snowy weather.
t. Thunder.
u. Ugly appearance, or threatening.
v. Visibility of distant objects.
w. Wet, or heavy dew.
z. Hazy.

To indicate great intensity of any feature, its symbol may be underlined; thus: r., heavy rain.

Weather Bureau Signals.—(See Storm Signals).

Wind.—In recording the force of the wind the scale devised by the late Admiral Sir F. Beaufort is employed in a modified form. According to this scale the wind varies from 0, a calm, to 12, a hurricane, the greatest velocity it ever attains. Originally in the lower grades of the scale the force of the wind was estimated from the speed imparted to a man-of-war of the early part of the nineteenth century sailing full and by; in the higher grades, from the amount of sail which the same vessel could carry when close-hauled; but reference is now made to a modern, steel, full-rigged ship, with average coefficient of fineness, deep loaded, with clean bottom; and also, in a separate space, to a sailing trawler of average size, cutter or yawl rigged, loaded, with clean bottom. This scale, conforming in the values of the velocity and corresponding pressure of the wind with the scale proposed by the International Hydrographic Bureau of 1925, is as shown below.

When steaming or sailing with any considerable speed, the apparent direction and force of the wind, as determined from a vane flag, or pennant aboard ship, may differ materially from the true direction and force, the reason being that the air appears to come from a direction and with a force dependent, not only upon the wind itself, but also upon the motion of the vessel. For instance, suppose that the wind has a velocity of 20 knots (force 5), and take the case of two vessels, each steaming 20 knots, the first with the wind dead aft, the second with the wind dead ahead. The former vessel will be moving with the same velocity as the air and in the same direction; the velocity of the wind relatively to the ship will thus be zero; on the vessel an apparent calm will prevail and the pennant will hang up and down. The latter vessel will be moving with the same velocity as the air, but in the opposite direction; the relative velocity of the two will thus be the sum of the two velocities, or 40 knots, and on the second vessel the wind will apparently have the velocity corresponding very nearly with a fresh gale. Again, it might be shown that in the case of a vessel steaming west at the rate of 20 knots, with the wind blowing from north with the velocity of 20 knots, the velocity with which the air strikes the ship as a result of the combined motion will be 28 knots, and the direction from which it comes will be NW. If, therefore, the effect

Beaufort No.	Seaman's description of wind	Mode of estimating for full-rigged ship	Mode of estimating for average sized sailing trawler	Specifications for use on land	Miles per hour (statute)	Equivalent in knots	Equivalent in meters per second	Equivalent pressure in millibars * (10^3 dynes per cm^2.)	Terms used in U. S. Weather Bureau forecasts
0	Calm	Full-rigged ship, all sails set, no headway.	No headway	Calm; smoke rises vertically.	Less than 1	Less than 1	Less than 0.3	Less than 0.005	
1	Light air	Just sufficient to give steerage way.	Sufficient to give good steerage way to fishing smacks, with "wind free."	Direction of wind shown by smoke drift, but not by wind vanes.	1–3	1–3	0.3–1.5	0.005–0.03	Light
2	Light breeze (slight breeze)	Speed of 1 or 2 knots, "full and by."	Fishing smacks with topsails and light canvas, "full and by," make up to two knots.	Wind felt on face; leaves rustle; ordinary vane moved by wind.	4–7	4–6	1.6–3.3	0.03–0.1	
3	Gentle breeze	Speed of 3 or 4 knots, "full and by."	Smacks begin to heel over slightly under topsails and light canvas, make up to 3 knots, "full and by."	Leaves and small twigs in constant motion; wind extends light flag.	8–12	7–10	3.4–5.4	0.1–0.2	Gentle
4	Moderate breeze	Speed of 5 or 6 knots, "full and by."	Good working breeze, smacks heel over considerably on a wind under all sail.	Raises dust and loose paper; small branches are moved.	13–18	11–16	5.5–8.0	0.2–0.5	Moderate
5	Fresh breeze	All plain sail, "full and by."	Smacks shorten sail	Small trees in leaf begin to sway; crested wavelets form on inland waters.	19–24	17–21	8.1–10.7	0.5–1.0	Fresh
6	Strong breeze	Ship "full and by" can just carry topgallant sails.	Smacks double-reef, gaff mainsail	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	25–31	22–27	10.8–13.8	1–1.5	Strong
7	Moderate gale (high wind)	Ship "full and by" can just carry whole upper topsails.	Smacks remain in harbor, and those at sea lie to.	Whole trees in motion; inconvenience felt in walking against wind.	32–38	28–33	13.0–17.1	1.5–2	
8	Fresh gale	Ship "full and by" can just carry reefed upper topsails and whole foresail.	Smacks take shelter if possible.	Breaks twigs off trees; generally impedes progress.	39–46	34–40	17.2–20.7	2–3	Gale
9	Strong gale	Ship "full and by" can just carry lower topsails and reefed foresail.	.....	Slight structural damage occurs (chimney pots and slate removed).	47–54	41–47	20.8–24.4	3–4.5	
10	Whole gale (heavy gale)	Ship "full and by" can only carry main lower topsail.	.....	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	55–63	48–55	24.5–28.3	4.5–6	Whole gale
11	Storm	Ship can only carry storm staysail or trysail.	.....	Very rarely experienced; accompanied by widespread damage.	64–75	56–65	28.4–33.5	6–8	
12	Hurricane	No canvas can stand	.....	.....	Above 75	Above 65	33.6 or above	Above 8	Hurricane

* One millibar equals approximately 10 kilograms per square meter or 2 pounds per square foot.

55252°—25.

of the speed of the ship is neglected the wind will be recorded as NW, force 7, when in reality it is north, force 5.

In order to make a proper allowance for this error and arrive at the true direction and force of the wind, Table 32 may be entered with the ship's speed and the apparent direction and force of the wind as arguments, and the true direction and force will be found.

Zenith.—That point in the heavens directly overhead of the observer, and 90° distant from every point of the horizon.

Zenith Distance.—The angular distance of a heavenly body from the zenith of the observer.

Part II

EXTRACTS FROM STEAMBOAT INSPECTION LAWS AND RULES (OCEAN AND COASTWISE) AND NAVIGATION LAWS OF THE UNITED STATES

Abandonment of Seamen.—Whoever, being master or commander of a vessel of the United States, while abroad, maliciously and without justifiable cause forces any officer or mariner of such vessel on shore, in order to leave him behind in any foreign port or place, or refuses to bring home again all such officers and mariners of such vessel whom he carried out with him, as are in a condition to return and willing to return, when he is ready to proceed on his homeward voyage, shall be fined not more than $500, or imprisoned not more than six months, or both.

Accident Reports.—The licensed officer in command of any vessel shall report in writing and in person to the board of local inspectors nearest the port of first arrival any accident to said vessel involving loss of life or damage to property to an approximate amount exceeding $100, and shall also report in the same manner any casualty or loss of life from whatever cause of any person on board such vessel and any stranding or grounding, whether or not any damage has been sustained by the vessel. If the accident happens upon the high seas or without the jurisdiction of inland waters, the board to whom the report is first made shall make the investigation; but if the accident occurs within the jurisdiction of inland waters, the report shall be transmitted to the board within whose jurisdiction the accident occurred, which board shall make the investigation, except in cases where, in the judgment of the Supervising Inspector General, better results may be obtained by another board conducting the investigation, in which case the Supervising Inspector General is authorized to direct such investigation by another board: Provided, That when from distance it may be inconvenient to report in person it may be done in writing only, and the report sworn to before any person authorized to administer oaths.

Whenever a vessel commanded by an officer licensed by the Steamboat Inspection Service collides with a lightship, buoy, or other aid to navigation under the jurisdiction of the Bureau of Lighthouses, or is connected with any such

collision, it shall be the duty of the licensed officer in command of such vessel to report the accident to the nearest board of local inspectors. When any collision of this character is reported to a board of local inspectors, those officers shall immediately transmit such information to the Superintendent of Lighthouses of the district in which the collision occurred.

Failure to promptly render the reports required shall be deemed sufficient cause for suspension or revocation of license.

Acids.—Acids shall be carried in carboys, on the guards or on deck, only by special license, or in such other places as prescribed by the inspectors.

Air Tanks.—(See Lifeboats.)

Alarm Bell.—All vessels of over 100 gross tons shall have all sleeping accommodations equipped with a sufficient number of alarm bells and so located as to warn all the occupants.

Where electric alarm bells are used they shall be of sufficient size to be heard clearly throughout the section for which they are provided, and shall be operated by an open switch from the pilot house or bridge. In no case, however, shall they be of a size less than six inches in diameter.

All vessels constructed with two or more passenger decks shall be equipped with an approved loudspeaker system with a sufficient number of stations so as to enable the officer in command to broadcast from the bridge to all passenger and crew quarters. The system shall be so designed and installed that it cannot be rendered inoperative at any station.

Alarm for Fire.—(See Fire Alarm Signal; Automatic Fire Alarm System.)

American Bureau of Shipping Rules.—In the inspection of hulls, boilers, and machinery of vessels, the rules promulgated by the American Bureau of Shipping respecting material and construction of hulls, boilers, and machinery, and the certificate of classification referring thereto, except where otherwise provided for by rules and regulations of Steamboat Inspection Service, shall be accepted as standard by the inspectors of this service.

Application to Use Petroleum as Fuel.—(See Fuel Oil Tanks.)

Automatic Fire-Alarm System.—(See Fire-detecting and Alarm System.)

Auxiliary Lighting System.—Provisions shall be made for an electric or other system of lighting, sufficient for all requirements of safety, in the different parts of the ship. There shall be a self-contained source capable of supplying, when necessary, this safety lighting system, and placed in the upper parts of the ship above the margin line.

The exit from every main compartment occupied by passengers or crew shall be continuously lighted by an emergency lamp. The power for these emergency lamps shall be so arranged that they will be supplied from the independent installation referred to in the preceding paragraph in the event of failure of the main generating plant.

Avenues of Escape.—(See Escape.)

Axes.—(See Fire Axes.)

Ballast.—(See Inclining Test.)

Barges.—(See Lifeboats.)

Barratry.—Whoever, on the high seas, or within the United States, wilfully and corruptly conspires, combines, and confederates with any other person, such other person being either within or without the United States, to cast away or otherwise destroy any vessel, with intent to injure any person that may have underwritten or may thereafter underwrite any policy of insurance thereon or on goods on board thereof, or with intent to injure any person that has lent or advanced, or may lend or advance, any money on such vessel on bottomry or respondentia; or whoever, within the United States, builds, or fits out, or aids in building or fitting out, any vessel with intent that the same be cast away or destroyed, with the intent hereinbefore mentioned, shall be fined not more than $10,000 and imprisoned not more than 10 years.

Bell for Alarm.—(See Alarm Bell.)

Bell Signals.—Steamers using the bell signals between the pilot house and engine room shall have a tube, of proper size, so arranged as to return the sound of the bell signals to the pilot house, and shall also be provided with a speaking tube or other device for the purpose of conversation between pilot house and engine room.

Nothing in the above shall be construed to prevent the use of the so-called telegraph now in use for conveying signals from the pilot house to the engine room, but in all cases where the telegraph is used the signal shall be repeated back. (See Examination and Test.)

Benzine.—(See Cargo and Stores prohibited on passenger steamers.)

Benzole.—(See Cargo and Stores prohibited on passenger steamers.)

Bilge Pipes.—Each and every steam vessel shall be fitted with a bilge pipe leading from each compartment of the vessel and connecting with a suitable marked valve to the main bilge pump in the engine room, and each compartment of all steam vessels shall be fitted with a suitable sounding pipe, the opening of which shall be accessible at all times, except that in compartments accessible at all times for examination, no sounding tubes are necessary.

Steam siphons may be substituted in each compartment for the bilge pipes.

Bill of Health.—Any vessel at any foreign port clearing for any port or place in the United States shall be required to obtain from the consul, vice-consul, or other consular officer of the United States at the port of departure, or from the medical officer where such officer has been detailed by the President for that purpose, a bill of health, in duplicate, in the form prescribed by the Secretary of the Treasury, setting forth the sanitary history and condition of said vessel, and that it has in all respects complied with the rules and regulations in such cases prescribed for securing the best sanitary condition of the said vessel, its cargo, passengers, and crew; and said consular or medical officer is required, before granting such duplicate bill of health, to be satisfied that the matters and things therein stated are true; and for his services in that behalf he shall be entitled to demand and receive such fees as shall by lawful regulation be allowed, to be accounted for as is required in other cases.

Any vessel clearing and sailing from any such port without such bill of health, and entering any port in the United States, shall forfeit to the United States not more than $5,000, the amount to be determined by the court, which shall be a lien on the same, to be recovered by proceedings in the proper district court of the United States.

Blue Prints.—(See Fuel Oil Tanks.)

Boarding and Search of Vessel.—If any master of a vessel coming into or having arrived at any port within the United States shall obstruct or hinder, or shall intentionally cause any obstructions or hindrance to any officer in lawfully going on board such vessel for the purpose of carrying into effect any of the revenue laws of the United States, he shall for every such offense be liable to a penalty of not more than $500 nor less than $50.

Boarding Vessel.—It shall not be lawful for the master of any vessel, not in distress, after the arrival of the vessel within any collection district of the United States, to allow any person or persons except a pilot, officer of the customs, or health officer, agents of the vessel, and consuls, to come on board of the vessel, or to leave the vessel, until the vessel has been taken in charge by an officer of the customs, nor, after charge so taken, without leave of such officer, until all the passengers, with their baggage, have been duly landed from the vessel.

For a violation of this provision, or for permitting or neglecting to prevent a violation thereof, the master of the vessel shall be liable to a fine not exceeding $1,000.

Each person violating this regulation shall be subject to a penalty of not more than $100 or imprisonment not to exceed six months, or both, in the discretion of the court.

Boats.—(See Lifeboats.)

Boat Drills.—(See Drills.)

Bridge, Persons Excluded from.—(See Only certain persons allowed in pilot house and on navigator's bridge.)

Bulkheads.—Every seagoing steam vessel and every steamer navigating the great northern and northwestern lakes constructed after July 1, 1912, carrying passengers, shall have a water-tight collision bulkhead. In vessels not over 200 feet in length this bulkhead shall be located about one-tenth the vessel's length from stem. In vessels over 200 and not over 350 feet in length the collision bulkhead shall be located about one-twelfth the vessel's length abaft the stem. In vessels over 350 and not over 500 feet in length it shall be located about one-fifteenth the vessel's length abaft the stem, and in vessels over 500 feet in length about one-sixteenth the vessel's length abaft the stem. Such vessels shall also have one water-tight bulkhead forward of and one abaft the engines and boilers, and in addition thereto shall have such other water-tight bulkheads as may be necessary to provide that there shall be no space between the bulkheads to exceed in length one-fifth the length of the vessel: Provided, however, That in no case shall the distance between the bulkheads be greater than 80 feet.

Screw steamers shall, in addition to the above-named bulkheads, have located at a suitable distance forward from sternpost a water-tight bulkhead to protect vessel from disaster in case of fracture of stern pipe.

Sailing vessels of over 700 tons carrying passengers for hire shall have a water-tight collision bulkhead. Such collision bulkhead shall be placed not less than 5 feet from the stem of the vessel.

Wooden steamers carrying passengers whose cargo is restricted to lumber exclusively shall only be required to have a water-tight collision bulkhead as described in the first paragraph of this section, also one water-tight bulkhead forward of and one abaft the engines and boilers.

All such bulkheads shall be of iron or steel plates not less than one-fourth inch thick and shall be securely fastened to suitable framework, which framework shall be properly and securely attached to the hull. Such bulkheads shall be strengthened by vertical bars of not less than $3\frac{1}{2}$ by $3\frac{1}{2}$-inch angle iron, spaced not more than 30 inches from center to center, and all steamers that are more than 10 feet deep in any hold shall have horizontal angle irons of not less than 3 by 3 inches on the reverse side, spaced not more than 4 feet from center to center, in addition to the vertical angle irons: Provided, That when any bulkheads are constructed of equal strength to the above-described bulkheads, they shall be allowed by the local inspectors.

All bulkheads shall reach to the main deck in single-decked vessels, otherwise to the deck next below the main deck, but in every case they shall reach to the deck next above the deep-load line.

The watertight subdivisions for every passenger vessel shall be as efficient as is possible, having regard to its intended service. This principle is given effect by the requirements of this section which provide for variations in the standard of subdivision according to the length of vessel and the degree to which the vessel approaches the exclusive passenger type, the highest standard being required in vessels of the greatest length engaged primarily in the carriage of passengers.

For further details: See "fifty-second Supplement to General Rules and Regulations," Page 43.

Bulkheads for Boiler-Rooms and Funnels.—Steamers more than 150 feet in length under the jurisdiction of the Steamboat Inspection Service carrying passengers or passengers and freight and contracted for after June 30, 1927, shall, if the boiler-room compartment extends above the main or other decks, have same protected through all such

decks by surrounding iron or steel bulkheads and the funnel or funnels protected by an iron or steel trunk or casing extending through and past all decks above their connection with the boiler-room compartment, and in such steamers where the boiler-room compartment does not extend above the main deck the funnel or funnels shall be protected by an iron or steel trunk or casing extending through and past all decks above their connection with the boiler or breeching. If the engine-room compartment extends above the main or other decks, same shall be protected through all such decks by surrounding iron or steel bulkheads and by an iron or steel ventilating shaft extending through and past the upper deck: Provided, That if such surrounding (engine-room) bulkheads are fitted with windows, the glass therein must be of a fire-resisting quality, fitted in metal sash frames.

Buoyant Apparatus.—On and after January 1, 1936, approved buoyant apparatus sufficient to accommodate 25 percent of all persons on board shall be required in addition to the lifesaving equipment on passenger vessels.

"The apparatus now in use that ocean passenger vessels were equipped with in order to comply with the International Convention may be accepted as complying with the requirements of the Steamboat Inspection Service."

Buoyant apparatus shall be stowed as follows:

(a) They shall not impede in any way prompt handling of lifeboats, or the marshaling of persons on board at launching stations.

(b) They shall be stowed in such manner as to be readily launched.

(c) They shall not be secured to the deck except by lashings which can be easily slipped; but they may be stowed in tiers one above the other, in which case the separate units shall be kept apart sufficiently to prevent sticking together, and supported on suitable distant pieces.

(d) Means shall be provided to prevent shifting.

Buoyant apparatus designed to accommodate 25 persons or more shall be fitted and equipped as follows:

Life line.—One life line properly secured entirely around the sides and ends of the buoyant apparatus, festooned to the gunwales in bights not longer than 3 feet with seine float in each bight.

Painter.—One painter of sufficient strength properly secured to the buoyant apparatus so that the buoyant

apparatus may be lowered from the deck where stored to the water. It shall be of good quality manila rope not less than 2 inches in circumference and at least equal in length to the height of the boat deck where stored to the vessels light seagoing draft plus 6 feet.

Self-Igniting Water Light.—One self-igniting water light of approved type.

Buoyant apparatus designed to accommodate less than 25 persons shall not be required to be equipped with a self-igniting water light. Such apparatus weighing less than 75 pounds shall not be required to have a painter for lowering.

Definition.—Buoyant apparatus is defined as buoyant deck seats, buoyant deck chairs, and light floats or other apparatus, having buoyancy, except life-boats, life rafts, life buoys, and life preservers, and no buoyant apparatus shall be approved which requires any adjustment or preparation.

General requirements.—Buoyant apparatus shall conform to the following general requirements:

(a) Its construction shall be of material and workmanship adequate for the purpose intended.

(b) It shall be effective and stable floating either side up.

(c) It shall have a line securely becketed around the outside and/or pendants to accommodate the number of persons allowed.

(d) It shall be of such size, strength, and weight as to be handled without mechanical appliances and thrown without damage from the deck where stowed.

(e) Its weight shall in no case exceed 200 pounds.

(f) It shall have air cases or equivalent buoyancy placed as near as possible to its sides.

Capacity.—

(a) The number of persons for which any type of buoyant apparatus may be deemed suitable shall be determined, subject to the result of the stability test by the least of the numbers ascertained, as follows: (1) Number of pounds of iron the apparatus is capable of supporting in fresh water, divided by 32; (2) The number of feet in the perimeter.

(b) The divisor given in paragraph (a) shall be required to be increased where the apparatus is designed so that persons supported are only partially immersed in the water, or where facilities are provided for climbing onto the top of it.

Stability.—Every type of buoyant apparatus shall be capable of supporting along any edge, without capsizing, a weight of iron 15 pounds per foot length suspended in the water from the life lines. Where the length of the edge is 4 feet or less the minimum weight of iron suspended from any edge shall be 60 pounds.

Test for Strength.—Every new type of buoyant apparatus shall be tested for strength by dropping a sample into the water from a height of 60 feet.

Air Tanks.—

(a) Material.—Where metal air tanks furnish the buoyancy of the apparatus, they shall be constructed of best quality copper or yellow metal of not less than 18 ounces to the superficial foot, and all joints shall be securely hook-jointed and efficiently soldered. Air tanks shall be fitted with suitable testing nipples and when testing same an air pressure of not more than 1 pound to the square inch shall be used.

(b) Size.—Air tanks shall be not more than 4 feet in length, but where more than 2 feet 6 inches in length or breadth they shall be efficiently stiffened by divisions or stays. At no time shall the cases be pierced for the attachment of wood divisions or stays, nor for any other purpose.

(c) Protection.—Air tanks shall not be placed in contact with metal iron work, and they shall be protected from injury by properly fitted solid wood casing and secured against movement therein.

Name Plate.—Each piece of buoyant apparatus shall have brass plate or its equivalent affixed thereon by the builder, and bearing his name and address, the words "Buoyant apparatus," the number of the apparatus, date of construction, dimensions, and number of persons allowed.

Buoys.—(See Life-Buoys.)

Cable for Communication.—On all vessels subject to inspection where the distance is more than 150 feet between deck houses, a wire cable shall be stretched between the deck houses at all times when the vessel is loaded and being navigated, this cable to be not less than 5 feet from the deck; and there shall be attached at all times to the cable a traveler with a line of sufficient continuous length to insure its operation, in order that communication between both ends of the vessel may be facilitated at all times: Provided, That, In addition to the traveler with the endless whip, as many loose rings with lanyards attached may be

placed on the cable as may be deemed necessary by the master in charge of the vessel. Failure to have such cable stretched and traveler attached at all times when the vessel is loaded and being navigated shall be sufficient cause for the suspension of the license of the master or officer in charge; Provided, That a fore and aft raised bridge shall be accepted in lieu of the wire cable and traveler.

Cable Protection.—The master of any vessel which, while engaged in laying or repairing submarine cables, shall fail to observe the rules concerning signals that have been or shall hereafter be adopted by the parties to the convention with a view to preventing collisions at sea; or the master of any vessel that, perceiving, or being able to perceive the said signals displayed upon a telegraph ship engaged in repairing a cable, shall not withdraw to or keep a distance of at least one nautical mile; or the master of any vessel that seeing or being able to see buoys intended to mark the position of a cable when being laid or when out of order or broken, shall not keep a distance of at least a quarter of a nautical mile, shall be guilty of a misdemeanor, and on conviction thereof, shall be liable to imprisonment for a term not exceeding one month, or to a fine of not exceeding $500.

Camphene.—(See Cargo and Stores prohibited on passenger steamers.)

Carbonic Acid Gas.—(See Fire Precautions.)

Cargo and Stores Prohibited on Passenger Steamers.—No loose hay, loose cotton, or loose hemp, camphene, nitroglycerin, naphtha, benzine, benzole, coal oil, crude or refined petroleum, or other like explosive burning fluids, or like dangerous articles, shall be carried as freight or used as stores on any steamer carrying passengers, nor oil that will not stand a fire test of 300° F.

Casing for Funnel.—(See Bulkheads for boiler-rooms and funnels.)

Casualty.—(See Accident Reports; Log Book.)

Certificate to Carry Gunpowder.—(See Gunpowder.)

Certificated Lifeboat Men.—(See Lifeboats and Liferafts.)

Change of Name.—No master, owner, or agent of any vessel of the United States shall in any way change the name of such vessel, or by any device, advertisement, or contrivance deceive or attempt to deceive the public, or any officer or agent of the United States, or of any State,

or any corporation or agent thereof, or any person or persons, as to the true name or character of such vessel, on pain of the forfeiture of such vessel.

The Commissioner of Navigation shall, under the direction of the Secretary of Commerce, be empowered to change the names of vessels of the United States on application of the owner or owners of such vessels when in his judgment there shall be sufficient cause for so doing.

Charges for Fire Extinguishers.—(See Fire Extinguishers.)

Classification Certificate.—(See American Bureau of Shipping rules.)

Clearance.—The master or person having the charge or command of any vessel bound to a foreign port, shall deliver to the collector of the district from which such vessel is about to depart, a manifest of all the cargo on board the same, and the value thereof, by him subscribed, and shall swear to the truth thereof; whereupon the collector shall grant a clearance for such vessel and her cargo, but without specifying the particulars thereof in the clearance, unless required by the master or other person having the charge or command of such vessel so to do. If any vessel bound to a foreign port departs on her voyage to such foreign port without delivering such manifest and obtaining a clearance, as hereby required, the master or other person having the charge or command of such vessel shall be liable to a penalty of $500 for every such offense.

Previous to a clearance being granted to any vessel, outward bound, the legal fees which shall have accrued on such vessel shall be paid at the offices where such fees are respectively payable; and receipts for the same shall be produced to the collector or other officer whose duty it may be to grant clearances, before a clearance is granted.

Whenever any clearance is granted to any vessel of the United States, duly registered as such, and bound on any foreign voyage, the collector of the district shall annex thereto, in every case, a copy of the rates or tariffs or fees which diplomatic and consular officers are entitled, by the regulations prescribed by the President, to receive for their services.

Clothing.—(See Warmth and Clothing.)

Coal Oil.—(See Cargo and Stores prohibited on passenger steamers.)

Collision.—Immediately call all hands to their stations,

swing out lifeboats and ascertain damage to vessel. Stop vessel, sound bilges, start pumps, and close all water-tight doors. If vessel is in danger, beach her if possible where she can be got off at least expense, land passengers, women and children first. In every case it shall be the duty of the master or person in charge of each vessel, if and so far as he can do so without serious danger to his own vessel, crew, and passengers (if any), to stay by the other vessel until he has ascertained that she had no need of further assistance, and to render to the other vessel, her master, crew, and passengers (if any) such assistance as may be practicable and as may be necessary in order to save them from any danger caused by the collision, and also to give to the master or person in charge of the other vessel the name of his own vessel and her port of registry, or the port or place to which she belongs, and also the name of the ports and places from which and to which she is bound. If he fails so to do, and no reasonable cause for such failure is shown, the collision shall, in the absence of proof to the contrary, be deemed to have been caused by his wrongful act, neglect, or default.

That every master or person in charge of a United States vessel who fails, without reasonable cause, to render such assistance or give such information as aforesaid shall be deemed guilty of a misdemeanor, and shall be liable to a penalty of $1,000, or imprisonment for a term not exceeding two years; and for the above sum the vessel shall be liable and may be seized by any person; one-half such sum to be payable to the informer and the other half to the United States.

Make entry of collision in the Official Log Book and report immediately to the nearest board of local inspectors. (See Accident Reports.)

Collision with Lightship, Buoy or Other Aid to Navigation.—(See Accident Reports.)

Condition of Vessel and Equipment.—It shall be the duty of the officer in charge of every steamer to see that all the equipments required by law are in complete working order and ready for immediate use; and the master of every steamer carrying passengers shall report monthly to the local inspectors the condition of the vessel and her equipment, and any neglect or omission on the part of the officer in command of such vessel to strictly enforce this rule shall be deemed cause for the suspension or revocation of the license of such officer.

Construction Standard.—(See American Bureau of Shipping Rules and 52nd Supplement General Rules and Regulations of Steamboat Inspection Service.)

Corporal Punishment.—Flogging and all other forms of corporal punishment are hereby prohibited on board of any vessel, and no form of corporal punishment on board of any vessel shall be deemed justifiable, and any master or other officer thereof who shall violate the aforesaid provisions of this section, or either thereof, shall be deemed guilty of a misdemeanor, punishable by imprisonment for not less than three months nor more than two years. Whenever any officer other than the master of such vessel shall violate any provision of this section, it shall be the duty of such master to surrender such officer to the proper authorities as soon as practicable, provided he has actual knowledge of the misdemeanor, or complaint thereof is made within three days after reaching port. Any failure on the part of such master to use due diligence to comply herewith, which failure shall result in the escape of such officer, shall render the master or vessel or the owner of the vessel liable in damages for such flogging or corporal punishment to the person illegally punished by such officer.

Cotton.—No baled cotton shall be received on any vessel carrying passengers unless it is securely bound and covered with bagging on at least three-fourths of its surface, including both ends of the bale.

Loose cotton (See Cargo and stores prohibited on passenger steamers.)

Crew List.—Before a clearance is granted to any vessel bound on a foreign voyage or engaged in the whale fishery, the master thereof shall deliver to the collector of the customs a list containing the names, places of birth and residence, and description of the persons who compose his ship's company; to which list the oath of the captain shall be annexed, that the list contains the names of his crew; together with the places of their birth and residence, as far as he can ascertain them; and the collector shall deliver him a certified copy thereof.

Crude Petroleum.—(See Cargo and Stores prohibited on passenger steamers.)

Damage to Property.—(See Accident Reports.)

Dangerous Articles.—(See Cargo and Stores prohibited on passenger steamers.)

Dangerous Places.—It shall be the duty of the in-

spectors when inspecting or reinspecting a vessel to see that all exposed and dangerous places, such as gears and machinery, are properly protected with covers, guards, or rails, in order that the danger of accidents may be minimized, and on vessels equipped with radio (wireless) the lead-ins shall be sufficiently incased or insulated to insure the protection of persons from accidental shock. Such lead-ins shall be located so as not to interfere with launching of lifeboats and life rafts.

Davits.—(See Lifeboats.)

Deadlights and Air Ports.—It shall be the duty of the inspectors when inspecting or reinspecting vessels to carefully examine all air ports and deadlights in the hull, and to satisfy themselves that the same are safe.

Air ports 16 inches or more in diameter in the hull of all passenger vessels that open into the passageways shall have a life line securely fastened overhead within the passageway. This life line shall be not less than 2 inches in circumference, knotted every 3 feet and of sufficient length to reach the water at the lightest sea-going draft.

Death from Negligence, Misconduct, etc.—Every captain, engineer, pilot, or other person employed on any steamboat or vessel, by whose misconduct, negligence, or inattention to his duties on such vessel the life of any person is destroyed, and every owner, charterer, inspector, or other public officer, through whose fraud, neglect, connivance, misconduct, or violation of law the life of any person is destroyed, shall be fined not more than $10,000, or imprisoned not more than ten years, or both: Provided, That when the owner or charterer of any steamboat or vessel shall be a corporation, any executive officer of such corporation, for the time being actually charged with the control and management of the operation, equipment, or navigation of such steamboat or vessel, who has knowingly and wilfully caused or allowed such fraud, neglect, connivance, misconduct, or violation of law, by which the life of any person is destroyed, shall be fined not more than $10,000, or imprisoned not more than 10 years, or both.

Deceased Seamen.—Whenever any seaman or apprentice belonging to or sent home on any merchant vessel, whether a foreign-going or domestic vessel, employed on a voyage which is to terminate in the United States, dies during such voyage, the master shall take charge of all moneys, clothes, and effects which he leaves on board, and

shall, if he thinks fit, cause all or any of such clothes and effects to be sold by auction at the mast or other public auction, and shall thereupon sign an entry in the official log book, and cause it to be attested by the mate and one of the crew, containing the following particulars:

First: A statement of the amount of money so left by the deceased.

Second: In case of a sale, a description of each article sold, and the sum received for each.

Third: A statement of the sum due to deceased as wages, and the total amount of deductions, if any, to be made therefrom.

In cases embraced by the preceding section, the following rules shall be observed:

First: If the vessel proceeds at once to any port in the United States, the master shall, within 48 hours after his arrival, deliver any such effects remaining unsold, and pay any money which he has taken charge of, or received from such sale, and the balance of wages due to the deceased, to the shipping commissioner at the port of destination in the United States.

Second: If the vessel touches and remains at some foreign port before coming to any port in the United States, the master shall report the case to the United States consular officer there, and shall give to such officer any information he requires as to the destination of the vessel and probable length of the voyage; and such officer may, if he considers it expedient so to do, require the effects, money, and wages to be delivered and paid to him, and shall, upon such delivery and payment, give to the master a receipt; and the master shall within 48 hours after his arrival at his port of destination in the United States produce the same to the shipping commissioner there. Such consular officer shall, in any case, indorse and certify upon the agreement with the crew the particulars with respect to such delivery and payment.

Third: If the consular officer does not require such payment and delivery to be made to him the master shall take charge of the effects, money, and wages, and shall, within 48 hours after his arrival at his port of destination in the United States, deliver and pay the same to the shipping commissioner there.

Fourth: The master shall, in all cases in which any seaman or apprentice dies during the voyage or engage-

ment, give to such officer or shipping commissioner an account, in such form as they may respectively require, of the effects, money, and wages so to be delivered and paid; and no deductions claimed in such account shall be allowed unless verified by an entry in the official log book, if there be any; and by such other vouchers, if any, as may be reasonably required by the officer or shipping commissioner to whom the account is rendered.

Fifth: Upon due compliance with such of the provisions of this section as relate to acts to be done at the port of destination in the United States, the shipping commissioner shall grant to the master a certificate to that effect. No officer of customs shall clear any foreign-going vessel without the production of such certificate.

Whenever any master fails to take such charge of the money or other effects of a seaman or apprentice during a voyage, or to make such entries in respect thereof, or to procure such attestation to such entries, or to make such payment or delivery of any money, wages, or effects of any seaman or apprentice dying during a voyage, or to give such account in respect thereof as is above directed, he shall be accountable for the money, wages, and effects of the seaman or apprentice to the district court in whose jurisdiction such port of destination is situate, and shall pay and deliver the same accordingly; and he shall, in addition, for every such offense, be liable to a penalty of not more than treble the value of the money or effects, or, if such value is not ascertained, not more than $200; and if any such money, wages, or effects are not duly paid, delivered, and accounted for by the master, the owner of the vessel shall pay, deliver, and account for the same, and such money and wages and the value of such effects shall be recoverable from him accordingly; and if he fails to account for and pay the same, he shall, in addition to his liability for the money and value, be liable to the same penalty which is incurred by the master for a like offense; and all money, wages, and effects of any seaman or apprentice dying during a voyage shall be recoverable in the courts and by the modes of proceeding by which seamen are enabled to recover wages due to them.

Whenever any seaman or apprentice dies in the United States, and is, at the time of his death, entitled to claim from the master or owner of any vessel in which he has served, any unpaid wages or effects, such master or owner

shall pay and deliver, or account for the same, to the shipping commissioner at the port where the seaman or apprentice was discharged, or was to have been discharged, or where he died.

Deposit of Register, Sea Letter, and Passport.—Every master of a vessel, belonging to citizens of the United States, who shall sail from any port of the United States, shall, on his arrival at a foreign port, deposit his register, sea letter, and Mediterranean passport with the consul or vice consul, if any there be at such port; and it shall be the duty of such consul or vice consul, on such master or commander producing to him a clearance from the proper officer of the port where his vessel may be, to deliver to the master all of his papers, if such master or commander has complied with the provisions of law relating to the discharge of seamen in a foreign country, and to the payment of the fees of consular officers.

Every master of any such vessel who refuses or neglects to deposit the papers as required by the preceding section, shall be liable to a penalty of $500, to be recovered by such consul or vice consul, in his own name, for the benefit of the United States, in any court of competent jurisdiction.

Desertion.—It shall be the duty of all consular officers to discountenance insubordination by every means in their power and, where the local authorities can be usefully employed for that purpose, to lend their aid and use their exertions to that end in the most effectual manner.

Disengaging Apparatus.—Excluding the emergency boats, not more than one type of disengaging apparatus shall be fitted in the lifeboats of a vessel.

Discharge in Foreign Ports.—Upon the application of the master of any vessel to a consular officer to discharge a seaman, or upon the application of any seaman for his own discharge, if it appears to such officer that said seaman has completed his shipping agreement, or is entitled to his discharge under any act of Congress or according to the general principles or usages of maritime law as recognized in the United States, such officer shall discharge said seaman, and require from the master of said vessel, before such discharge shall be made, payment of the wages which may then be due said seaman; but no payment of extra wages shall be required by any consular officer upon such discharge of any seaman except as provided in this Act.

If any consular officer, when discharging any seaman, shall neglect to require the payment of and collect the arrears of wages and extra wages required to be paid in the case of the discharge of any seaman, he shall be accountable to the United States for the full amount thereof. The master shall provide any seaman so discharged with employment on a vessel agreed to by the seaman, or shall provide him with one month's extra wages, if it shall be shown to the satisfaction of the consul that such seaman was not discharged for neglect of duty, incompetency, or injury incurred on the vessel. If the seaman is discharged by voluntary consent before the consul, he shall be entitled to his wages up to the time of his discharge, but not for any further period. If the seaman is discharged on account of injury or illness, incapacitating him for service, the expenses of his maintenance and return to the United States shall be paid from the fund for the maintenance and transportation of destitute American seamen: Provided, That at the discretion of the Secretary of Commerce, and under such regulations as he may prescribe, if any seaman incapacitated from service by injury or illness is on board a vessel so situated that a prompt discharge requiring the personal appearance of the master of the vessel before an American consul or consular agent is impracticable, such seaman may be sent to a consul or consular agent, who shall care for him and defray the cost of his maintenance and transportation, as provided in this paragraph.

Whenever a vessel of the United States is sold in a foreign country and her company discharged, it shall be the duty of the master to produce to the consular officer a certified list of the ship's company, and also the shipping articles, and besides paying to each seaman or apprentice the wages due him, he shall either provide him with adequate employment on board some other vessel bound to the port at which he was originally shipped, or to such other port as may be agreed upon by him, or furnish the means of sending him to such port, or provide him with a passage home, or deposit with the consular officer such a sum of money as is by the officer deemed sufficient to defray the expenses of his maintenance and passage home; and the consular officer shall indorse upon the agreement with the crew of the ship which the seaman or apprentice is leaving the particulars of any payment, provision, or deposit made under this section. A failure to comply with

the provisions of this section shall render the owner liable to a fine of not exceeding $50.

Whenever on the discharge of a seaman in a foreign country by a consular officer on his complaint that the voyage is continued contrary to agreement, or that the vessel is badly provisioned or unseaworthy, or against the officers for cruel treatment, it shall be the duty of the consul or consular agent to institute a proper inquiry into the matter, and, upon his being satisfied of the truth and justice of such complaint, he shall require the master to pay to such seaman one month's wages over and above the wages due at the time of discharge, and to provide him with adequate employment on board some other vessel, or provide him with a passage on board some other vessel bound to the port from which he was originally shipped, or to the most convenient port of entry in the United States, or to a port agreed to by the seaman.

Discharge in Foreign Trade.—All seamen discharged in the United States from merchant vessels engaged in voyages from a port in the United States to any foreign port, or, being of the burden of 75 tons or upward, from a port on the Atlantic to a port on the Pacific, or vice versa, shall be discharged and receive their wages in the presence of a duly authorized shipping commissioner under this Title, except in cases where some competent court otherwise directs; and any master or owner of any such vessel who discharges any such seaman belonging thereto, or pays his wages within the United States in any other manner, shall be liable to a penalty of not more than $50.

Every master shall, not less than 48 hours before paying off or discharging any seaman, deliver to him, or, if he is to be discharged before a shipping commissioner, to such shipping commissioner, a full and true account of his wages, and all deductions to be made therefrom on any account whatsoever; and in default shall, for each offense, be liable to a penalty of not more than $50. No deduction from the wages of any seaman except in respect of some matter happening after such delivery shall be allowed unless it is included in the account delivered; and the master shall, during the voyage, enter the various matters in respect to which such deductions are made, with the amounts of the respective deductions as they occur, in the official log book, and shall, if required, produce such book at the time of the payment of wages, and also, upon the hearing, before any

competent authority, of any complaint or question relating to such payment.

Upon the discharge of any seaman, or upon the payment of his wages, the master shall sign and give him a certificate of discharge, specifying the period of his service and the time and place of his discharge; and every master who fails to sign and give to such seaman such certificate and discharge shall, for each such offense, incur a penalty not exceeding $50. But whenever the master shall discharge his crew or any part thereof in any collection district where no shipping commissioner has been appointed he may perform for himself the duties of such commissioner.

Draft.—All vessels of 50 gross tons and over, under the jurisdiction of the Steamboat Inspection Service, shall have the draft of the vessel plainly and legibly marked upon the stem and upon the sternpost or rudderpost or at such other place at the stern of the vessel as may be necessary for easy observance. The draft shall be taken from the bottom of the lowest part of the keel to the surface of the water, the bottom of the mark to indicate the draft in feet.

The master of every seagoing vessel shall, whenever leaving port, enter the maximum draft of his vessel in the log book.

Drills.—(See Emergency Signals.)

Dry Dock.—Whenever any vessel is placed upon the dock for repairs it shall be the duty of the master, owner, or agent to report the same to the board of local inspectors of that district, so that a thorough inspection may by them be made to determine what is necessary to make such vessel seaworthy if the condition or age of the vessel, in the judgment of the inspectors, renders such examination necessary.

Dumping into Navigable Waters.—It shall not be lawful to throw, discharge, or deposit, or cause, suffer, or procure to be thrown, discharged, or deposited either from or out of any ship, barge, or other floating craft of any kind, or from the shore, wharf, manufacturing establishment, or mill of any kind, any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state, into any navigable water of the United States, or into any tributary of any navigable water from which the same shall float or be washed into such navigable water; and it shall not be lawful to deposit, or cause, suffer, or procure, to be depos-

ited material of any kind in any place on the bank of any navigable water, or on the bank of any tributary of any navigable water, where the same shall be liable to be washed into such navigable water, either by ordinary or high tides, or by storms or floods, or otherwise, whereby navigation shall or may be impeded or obstructed.

Any person violating any provision of this Act shall be guilty of a misdemeanor, and on conviction thereof shall be fined for each offense not exceeding $1,000.

Electric Installation.—On all vessels contracted for after June 30, 1928, using electricity for any purpose, the installation shall be in keeping with the best modern practice.

Wires shall be armored or run in approved iron conduits or moldings.

Iron conduit or armored casing shall be required in bunkers, cargo spaces, storerooms, etc., and in all places where the leads are liable to mechanical injury. Joints in wiring shall be avoided as far as possible in the above-named spaces, and where joints are necessary they shall be made in metal boxes, readily accessible and protected in the same manner as the leads.

When wires are led through beams, frames, or non-water-tight bulkheads, they shall be carried either in iron conduits, armored casing, or protected by hard rubber, or other equivalent bushings.

When wires are carried through water-tight decks or bulkheads, they shall be provided with a suitable stuffing box or deck or bulkhead. Where such points are liable to mechanical injury, they shall be protected by suitable boxes or cages.

In locating the wiring system as a whole, care shall be taken to provide accessibility for examination and repair. Special care shall be taken to avoid any arrangement which might permit the lodgment of standing water, and when necessary, openings in conduits or drains shall be installed to accomplish this purpose.

All fixtures, taps, joints, and splices shall be fitted with metal boxes. Boxes in cargo and machinery spaces, galley, and those exposed to weather shall be water-tight.

Splices shall be so joined as to be both mechanically and electrically secure without solder. They shall then be soldered and properly insulated and further protected by waterproof tape.

Changes or alterations in the electrical installations of vessels now in service shall be in accordance with this rule.

Special attention shall be given by the inspectors in the examination of present installation to see that it is of such nature as to preclude any danger of fire, giving particular attention to wiring which is carried through wooden bulkheads, partitions, etc.

Emergency Signals.—The general fire alarm signal shall be a continuous rapid ringing of the ship's bell for a period not less than 10 seconds supplemented by the continuous ringing of the general alarm bells for not less than 10 seconds. For dismissal from fire alarm stations, the general alarm bells shall be sounded 3 times, supplemented by three short blasts of the whistle. The signal for boat drill or boat stations shall be more than 6 short blasts and one long blast of the whistle, supplemented by the same signal on the general alarm bells. Where whistle signals are used for handling boats, they shall be as follows:

To lower boats 1 short blast of the whistle.

To stop lowering the boats 2 short blasts of the whistle.

For dismissal from boat stations 3 short blasts of the whistle.

The master of any vessel may establish such other emergency signal, in addition to the above, as will provide that all the officers and all the crew and passengers of the vessel will have positive and certain notice of the existing emergency.

The master may organize a squad to be used for emergency duties (other than a general emergency), or crew practices, and the nature of the signals or other means for assembling the squad remains within the discretion of the master. Such signals should not conflict with the navigational signals or the signals used for a general alarm.

It shall be the duty of the master or the mate or officer next in command, once at least in each week, to call all hands to quarters and exercise them in discipline, and, weather permitting, in the unlashing and swinging out of the lifeboats, the closing of all hand or power operated watertight doors which are in use at sea, closing all fire doors and fire screens, the use of fire pumps and all other apparatus for the safety of life on board of such vessels, with special regard for the drill of the crew in the method of adjusting life preservers and educating passengers and others in this procedure, and to see that all the equipments

required by law are in complete working order for immediate use; the fact of exercise of the crew, as herein contemplated shall be entered upon the vessel's log book.

The rule relating to fire and boat drills contemplates that such drills shall be conducted precisely as though an emergency existed. To accomplish the purpose of the rule, lifeboat covers and strongbacks shall be removed, plugs or caps put in place, boat ladders secured in position for use, painters carried forward and secured so as to provide a good lead and slack to hold the boat in position under the davits when in the water.

The person in charge of each lifeboat or life raft should have a list of its crew and should see that the men under his orders are acquainted with their several duties. The hand pumps and fire pumps shall be operated long enough and a sufficient number of outlets used to insure that such equipment is in order and effectual. The motor and the hand operated propeller gear of each lifeboat shall be operated for a period of not less than 5 minutes once at least in every seven days, in order that it may be ready for service at any time. Such operation shall be a part of the lifeboat drill and the fact of such operation shall be made a part of the report of such drill. When oxygen breathing apparatus, gas masks, or other special equipment is carried, certain members of the crew shall be trained in the use of the equipment.

The entries in the vessel's log book relating to the exercise of the crew in fire and boat drills shall state the day of the month and the hour when so exercised, length of time of the drill, number on the boats swung out, number of lengths of hose used, and a statement of the condition of all fire and life saving apparatus.

Any neglect or omission on the part of the officer in command of such vessels to strictly enforce the provisions of this rule shall be deemed cause for suspension or revocation of the license of such officer.

It shall be the duty of the inspectors to require the officers and crew of all such vessels to perform the aforesaid drills and discipline in the presence of said inspectors at intervals sufficiently frequent to assure the said inspectors by actual observance that the foregoing requirements of this section are complied with.

The master of every passenger vessel shall report monthly, the day and date of such exercise and drill, the number of lifeboats on board and the number on the boats

that were swung out at each drill, the condition of the vessel and her equipments, and also the number of passengers carried.

These reports shall be made to the office of the Supervising Inspector of the district where the vessel was last inspected. That officer will forward the reports to the Board of Local Inspectors in which district the vessel operated during the greater part of the month to which the report relates, through the office of the proper Supervising Inspector.

Three copies of this section shall be furnished every vessel carrying passengers and one to all other vessels to which this section applies, to be framed under glass and posted in conspicuous places about the vessel.

Enrolled Vessels.—Vessels of 20 tons and upward, enrolled in pursuance of this Title, and having a license in force, or vessels of less than twenty tons, which, although not enrolled, have a license in force, as required by this Title, and no others, shall be deemed vessels of the United States entitled to the privileges of vessels employed in the coasting trade or fisheries.

Any vessel of the United States, navigating the waters of the northern, northeastern, and northwestern frontiers, otherwise than by sea, shall be enrolled and licensed in such form as other vessels; such enrollment and license shall authorize any such vessel to be employed either in the coasting or foreign trade on such frontiers, and no certificate of registry shall be required for vessels so employed. Such vessels shall be, in every other respect, liable to the regulations and penalties relating to registered and licensed vessels.

Enrolled and Licensed Vessels in Foreign Trade.—If any vessel, enrolled or licensed, shall proceed on a foreign voyage, without first giving up her enrollment and license to the collector of the district comprehending the port from which she is about to proceed on such voyage, and being duly registered by such collector, every such vessel, together with her tackle, apparel, and furniture, and the merchandise so imported therein, shall be liable to seizure and forfeiture.

If the port from which any vessel so enrolled or licensed is about to proceed on a foreign voyage is not within the district where such vessel is enrolled, the collector of such district shall give to the master of such vessel a certificate,

specifying that the enrollment and license of such vessel have been received by him, and the time when it was so received; which certificate shall afterward be delivered by the master to the collector who may have granted such enrollment and license.

Entry of American Vessels.—Except as otherwise provided by law, and under such regulations as the Secretary of Commerce may prescribe, the master of a vessel of the United States arriving in the United States from a foreign port or place shall, within 48 hours after its arrival within the limits of any customs collection district, make formal entry of the vessel at the custom-house by producing and depositing with the collector the vessel's crew list, its register, or document in lieu thereof, the clearance and bills of health issued to the vessel at the foreign port or ports from which it arrived, together with the original and one copy of the manifest, and shall make oath that the ownership of the vessel is as indicated in the register and that the manifest was made out in accordance with law.

Equipment.—All the equipments of a vessel, such as buckets, hose, axes, boats, oars, rafts, life preservers, floats, barrels, and tanks, shall be painted or branded with the name of the vessel upon which they are used.

Articles of equipment for lifeboats, life rafts, and buoyant apparatus shall be of good quality, efficient for the purpose they are intended to serve, and kept in good condition.

Lifeboats, life rafts, and buoyant apparatus shall be fully equipped before the vessel leaves port, and the equipment shall remain in the boat, raft, or buoyant apparatus throughout the voyage. It shall be unlawful to stow in any boat, raft, or buoyant apparatus articles other than those herein required.

Loose equipment shall be securely attached to the boat, raft, or buoyant apparatus to which it belongs.

No lifeboat, lifeboat-disengaging apparatus, life raft, life preserver, fire extinguisher, fire extinguishing apparatus, or other equipment required to be approved by Title LII, Revised Statutes, shall be used on any vessel inspected and certificated by this Service which shall not first be approved by the Board of Supervising Inspectors and also by the Secretary of Commerce. (See Lifeboats.)

Escape.—(See Exits.)

Examination and Test.—On all ocean vessels under the

jurisdiction of the Steamboat Inspection Service making voyages of more than 48 hours' duration, the entire steering gear, the whistle, the means of communication and the signaling appliances between the bridge or pilot house and engine room shall be examined and tested by a licensed officer of the vessel within a period of not more than 12 hours before leaving port. All such vessels making voyages of less than 48 hours' duration shall be so examined and tested at least once in every week. The fact and time of such examination and test shall be recorded in the ship's log book.

Exits.—Each compartment of every vessel where passengers or crew may be quartered or anyone may be employed shall be provided with at least two means of exit so arranged that should one not be available the other will be. One of these exits must be independent of any watertight doors and should give as direct access to the open deck as practicable.

Where such exits are not readily discernible they shall be clearly marked with appropriate notices.

Extra Steering Apparatus.—Vessels shall be provided with an auxiliary steering apparatus which, however, may be of less power than the main apparatus, and need not be worked by steam or other mechanical power, provided adequate arrangements for manual operation are practicable. A duplicate main steering power plant shall be considered as an auxiliary steering apparatus within the meaning of this paragraph.

A spare tiller properly fitted to the rudder stock with relieving tackle should be provided except in particular cases subject to the special approval of the Bureau, where the design and arrangement of the main tiller are considered such as to warrant its omission.

An efficient brake shall be provided so that the change from one gear or tiller to another may be effected when necessary.

Where reasonable and practicable, there shall be provided an efficient means of communication between the pilot house and the emergency steering station, and the steering-engine room. Likewise, the emergency steering wheel shall be located on the after weather deck.

Failure of Main Lighting Plant.—(See Auxiliary Lighting System.)

Failure to Produce Crew.—The master of every vessel

bound on a foreign voyage or engaged in the whale fishery shall exhibit the certified copy of the list of the crew to the first boarding officer at the first port in the United States at which he shall arrive on his return, and also produce the persons named therein to the boarding officer, whose duty it shall be to examine the men with such list and to report the same to the collector; and it shall be the duty of the collector at the port of arrival, where the same is different from the port from which the vessel originally sailed, to transmit a copy of the list so reported to him to the collector of the port from which such vessel originally sailed. For each failure to produce any person on the certified copy of the list of the crew the master and owner shall be severally liable to a penalty of $400, to be sued for, prosecuted, and disposed of in such manner as penalties and forfeitures which may be incurred for offenses against the laws relating to the collection of duties; but such penalties shall not be incurred on account of the master not producing to the first boarding officer any of the persons contained in the list who may have been discharged in a foreign country with the consent of the consul or vice-consul there residing, certified in writing, under his hand and official seal, to be produced to the collector with the other persons composing the crew, nor on account of any such person dying or absconding or being forcibly impressed into other service of which satisfactory proof shall also be exhibited to the collector.

Falls.—(See Lifeboats.)

Fire Alarm Signal.—(See Emergency Signals.)

Fire Alarm System.—(See Fire Detecting and Sprinkler System.)

Fire Axes.—All steamers navigating oceans are required to be provided with fire axes as follows: Not over 10 tons, 1 axe; over 10 and not over 50 tons, 1 axe; over 50 and not over 200 tons, 2 axes; over 200 and not over 500 tons, 4 axes; over 500 and not over 1,000 tons, 6 axes; over 1,000 tons, 8 axes.

All axes shall be located so as to be readily found in time of need, shall not be used for general purposes, and shall be kept in good condition.

Fire Detecting and Sprinkler System.—All passenger vessels of more than 150 feet in length, with sleeping quarters for passengers, shall be equipped with an automatic fire-detecting system or an automatic sprinkler

system of a type approved by the Board of Supervising Inspectors.

An automatic electrical system, a pneumatic-tube system or an automatic water-sprinkler system shall be installed in all enclosed quarters for passengers, officers, and crew, including sleeping accommodations, passageways, lockers, linen rooms, paint, oil, and lamp rooms, carpenter shops, galleys, and such other compartments as may be deemed necessary.

Concealed overhead spaces on existing passenger vessels shall be protected by fire-detecting or an automatic sprinkler system.

A smoke-detecting system or an automatic electrical system, the detectors of which may be replaced without ingress to the compartments in which they are located, shall be installed in all cargo compartments, except cargo compartments accessible to passengers or crew while the vessel is being navigated, which spaces shall be fitted with a water-sprinkler system.

Engine rooms, boiler rooms, bath rooms, small clothes closets, and other similar places, when so constructed as to minimize the fire hazard, may not be required to have the foregoing installations.

All fire-fighting equipment, fire doors, and fire screens, watertight doors, etc., shall be visible and easily identified and so located as to be readily available at all times.

The director may designate whether an automatic fire-detecting system or an automatic sprinkler system shall be used, depending upon the hazard.

Fire Duties.—(See Emergency Signals.)

Fire Extinguishers.—All vessels carrying passengers, including pleasure vessels, shall be provided with such number of good and efficient portable fire extinguishers, approved by the Board of Supervising Inspectors as is hereafter prescribed; viz:

Vessels less than 150 feet in length shall have at least 2 fire extinguishers on each passenger deck; vessels 150 feet and over in length shall be provided with at least 1 fire extinguisher for every 150 linear feet of corridor length or fraction thereof, in the spaces occupied by passengers and crew. In all public spaces extinguishers shall be located not more than 150 feet apart.

Freight and towing vessels shall be provided with chemical fire extinguishers as follows: Vessels of over 15

and not over 50 gross tons, 1; vessels of over 50 and not over 100 gross tons, 2; vessels of over 100 and not over 500 gross tons, 3; vessels of over 500 and not over 1,000 gross tons, 6; vessels of over 1,000 gross tons, 8.

The above tables of required fire extinguishers are based on the capacity of the ordinary machine, which is about 2½ gallons, and no fire extinguisher of larger capacity shall be allowed a greater rating than that of the ordinary machine. Fire extinguishers of approved types of less capacity are allowable under the above rules when their total contents equal the required quantity.

Extra charges shall be carried on board for 50% of each class of fire extinguisher carried. If 50% of each class of fire extinguisher carried gives a fractional result, extra charges shall be provided for the next largest whole number. Example: Fire extinguishers carried, 1: extra charges required, 1; extinguishers, 2; extra charges 1; extinguishers, 3; extra charges, 2, etc.

Fire extinguishers shall be located in such parts of the vessel as in the judgment of the local inspectors will be most convenient and serviceable in case of emergency, and so arranged that they may be easily removed from their fastenings. Every fire extinguisher thus provided for shall be discharged and examined at each annual inspection.

Recharges, particularly the acid, used in charging soda-and-acid type of fire extinguishers, must be packed in such manner that the filling operation can be performed without subjecting the person doing the recharging to undue risk of acid burns and shall be contained in Crown stopper type of bottle.

Fire Indicator.—(See Fire Detecting and Sprinkler System.)

Fire Precautions.—Every steamer carrying passengers or freight shall be provided with suitable pipes and valves attached to the boiler to convey steam into the hold and to the different compartments thereof to extinguish fire, or such other suitable apparatus as may be prescribed by the regulations of the Board of Supervising Inspectors, with the approval of the Secretary of Commerce, for extinguishing fire in the hold and compartments thereof by the introduction through pipes into such holds and compartments of carbonic acid gas or other fire-extinguishing gas or vapor. (See Fire Detecting and Sprinkler System.) The main pipes and their branches to convey steam from the boilers to the

hold and separate compartments of the same shall be not less than $1\frac{1}{2}$ inches in diameter. Steam pipes of not less than three-fourths of an inch in diameter shall be led to all lamp lockers, oil rooms, and like compartments, which lamp lockers, oil rooms, and compartments, in all classes of vessels, shall be wholly and tightly lined with metal. (See Fire Detecting and Sprinkler System.) All branch pipes leading into the several compartments of the hold of the vessel shall be supplied with valves, the handles distinctly marked to indicate the compartment or parts of the vessel to which they lead.

These valves or their handles shall be placed in not more than two places on the most suitable and accessible deck of the vessel and so arranged that all can be inclosed in cabinets, boxes, or casings, the doors of which shall be plainly marked with the words "Steam Fire Apparatus."

On all oil-tank steamers the valves, instead of being located near the hatches on the upper deck, shall be all in an accessible house in which the operator is well protected from heat and smoke: Provided, That on oil-tank steamers a main line of steam smothering pipe of sufficient area to supply all branch pipes leading from the same to the tanks may be run the entire length of the deck, and only the main stop valve of the main line shall be required to be housed. All branch pipes shall be provided with valves which shall be left open at all times, so that the steam may enter all compartments simultaneously. Such branches as may not be required after the fire is definitely located may be shut off, in order that the entire system may be concentrated on one tank.

Provided, That carbonic-acid gas or other extinguishing gases or vapors may be substituted in place of steam as aforesaid and for the above-described purposes, and may also be used in the fire hold, fire-room bilges, and pump-rooms on vessels using oil for fuel, when such gas or vapor and the apparatus for storing, producing, and distributing same shall have been approved by the Board of Supervising Inspectors. (See Fire Detecting and Sprinkler System.)

Provided further, That pipes for conveying steam from the boilers, or pipes for conveying carbonic acid gas or other extinguishing vapors for the purpose of extinguishing fire, shall not be led into the cabins or into other passengers' or crew's quarters.

Provided further, That in the compartments or oil tanks

of oil-tank vessels the foam-type fire-extinguishing system may be substituted for steam, gases, or other extinguishing vapors, and may also be used in the fire hold, fire-room bilges, and pump rooms on vessels using oil for fuel when such foam-type fire-extinguishing system is completely installed in accordance with drawings or blue-prints and specifications approved by the supervising inspector of the district where it is installed. The foregoing system may be of a type employing either two-solution tanks or a generator using an approved dry chemical mixture.

Motor vessels of 50 gross tons or over, carrying passengers or freight for hire, shall be equipped with efficient means for extinguishing fire in the hold and the different compartments thereof in which cargo is carried; also in lamp lockers, oil rooms, and like compartments.

The use of glass lamps shall be prohibited on any vessel under the jurisdiction of the Steamboat Inspection Service unless the same are securely fitted into suitable metal brackets.

Every stove used on board of any vessel shall be well and securely fastened, so as to prevent it from being moved or overthrown, and all woodwork or other ignitable substances about the boilers, chimneys, cook-houses, and stove-pipes, exposed to ignition shall be thoroughly shielded by some incombustible material in such a manner as to leave the air to circulate freely between such material and woodwork or other ignitible substance; and before granting a certificate of inspection the inspector shall require all other necessary provisions to be made throughout such vessel to guard against loss or danger from fire.

Steam smothering lines shall be tested with at least 50 pounds air pressure with ends of the smothering lines capped, or by blowing steam through the lines, and a survey made for detecting corrosion and defects, using the hammer test or such other means as may be necessary.

Fire Precautions in Fireroom of Steamers Using Oil as Fuel.—On all vessels of over 500 gross tons using oil as fuel there shall be in each fireroom a metal tank containing 50 gallons of sand, fitted with a scoop or shaker, for fire purposes; also two or more approved fire extinguishers of not less than $2\frac{1}{2}$ gallons' capacity nor more than 5 gallons' capacity each, placed accessible to the fireroom and ready for immediate use: Provided, however, That steamers of 500 gross tons and under using oil as fuel may be fitted with

metal tanks containing 25 gallons of sand, and one approved fire extinguisher of not less than 2½ gallons' capacity nor more than 5 gallons' capacity.

Fire Pumps and Hose.—Steamers required to be provided with double-acting steam fire pumps or other equivalents for throwing water shall be equipped with such pumps according to their tonnage, as follows: Steamers over 20 tons and not exceeding 150 gross tons shall have not less than 50 cubic inches pump-cylinder capacity. Steamers of over 150 and under 3,000 tons shall have not less than one-third of 1 cubic inch pump-cylinder capacity for every gross ton. Steamers of 3,000 gross tons and over shall have pump cylinder of not less than 1,000 cubic inches' capacity. This rule shall apply only to pumps installed after June 30, 1907, and all pumps now approved and in use or installed before said date shall be accepted if complying with requirements of law and regulations in force at the time of the adoption of this rule.

Upon such steamers fire mains shall be led from the pumps to all decks, with sufficient number of outlets arranged so that any part of the steamer can be reached with water with the full capacity of the pumps and by means of a single 50-foot length of hose from at least one of said outlets. On all classes of steamers every such pump shall be fitted with a gauge and a relief valve of such size as to restrict the pressure of water to 100 pounds per square inch.

Steamers are not restricted to any particular proportions for fire pumps. Any dimensions that will attain the requirements specified above, or greater in capacity, may be allowed: Provided, however, That all hydrant connections be supplied with suitable spanners.

The capacity of the pipes and hose leading from the pumps shall in no case be less than that of the discharge opening of the pump: Provided, however, That the pipe and hose shall in no instance be less than 1½ inches in internal diameter.

And provided further, That steamers of 15 tons and under may be allowed to use hose of three-fourths of an inch in internal diameter, but in no case shall it be less than the discharge openings of the pumps, it being further provided that open boats of less than 10 gross tons that are fully equipped with buckets, as required by these rules and regulations, shall not be required to carry hose.

Every steamer exceeding 150 gross tons and otherwise provided for shall be provided with one good double-acting fire pump to be worked by hand: Provided, That when a steam pump is equipped to work by hand the same shall be accepted as a hand fire pump. Each chamber shall be of sufficient capacity and the stroke so regulated that not less than 100 cubic inches of water shall be displaced by each stroke of the piston. Two smaller pumps may be allowed to take the place of the one pump of 100 cubic inches' capacity provided for in this section when their combined capacity equals or exceeds 100 cubic inches. Each pump shall be placed in the most suitable part of the vessel for efficient service, having suitable, well-fitted hose to such pump long enough to reach to all parts of the vessel. Pumps may be connected to a pipe line having sufficient number of outlets so arranged that any part of the vessel can be reached with water by means of a single 50-foot length of hose from at least one of said outlets, pumps to be kept at all times in perfect order, with brakes, and hose coupled on ready for immediate use: Provided, That on freight steamers having hulls constructed entirely of metal only such hose shall be required as may be necessary to reach all cabins or superstructures, such hose to be coupled on at all times.

All steam fire pumps required shall be supplied with connecting pipes leading to the hold of the vessel with stop-cocks or shut-off valves attached and so arranged that such pumps may be used for pumping and discharging water overboard from the hold.

All hose required on steam vessels for fire purposes shall be tested to a pressure of 100 pounds to the square inch at each inspection, and it shall be the duty of the local inspectors at each annual inspection to see that the couplings are securely fastened to the hose by suitable external or internal clamps, and at least one length of such hose shall be kept at all times attached to such outlet of the fire main and provided with a suitable nozzle: Provided, That on freight steamers where the keeping of such hose coupled on interferes with the loading or unloading of cargo they may be removed during such loading or unloading.

All pipes used as mains for conducting water from fire pumps on board steam vessels in place of hose shall be of wrought iron, brass, or copper, with wrought-iron, brass, or composition hose connections.

Suction pipes for all pumps on steam vessels shall be so arranged as to have an area of opening sufficiently large to supply water when pumps are working at full capacity.

Motor vessels of 50 gross tons and over, carrying passengers for hire, shall be equipped with pumps for throwing water according to the tonnage of steam vessels, and equipped as prescribed above.

Flash Lights.—(See Auxiliary Lighting System; Lifeboat Equipment.)

Fog Bell.—The efficient fog bell required upon vessels by law shall be held to mean a bell not less than 8 inches in diameter from outside to outside, and constructed of bronze or brass or other material equal thereto in tone and volume of sound, and located where the sound shall be the least obstructed.

Forgery.—Whoever shall falsely make, forge, counterfeit, or alter any instrument in imitation of, or purporting to be, an abstract or official copy or certificate of the recording, registry, or enrollment of any vessel, in the office of any collector of the customs, or a license to any vessel for carrying on the coasting trade or fisheries of the United States, or a certificate of ownership, pass, passport, sea letter, or clearance, granted for any vessel, under the authority of the United States, or a permit, debenture, or other official document granted by any collector or other officer of the customs by virtue of his office; or whoever shall utter, publish, or pass, or attempt to utter, publish, or pass, as true, any such false, forged, counterfeited, or falsely altered instrument, abstract, official copy, certificate, license, pass, passport, sea letter, clearance, permit, debenture, or other official document herein specified, knowing the same to be false, forged, counterfeited, or falsely altered, with an intent to defraud, shall be fined not more than $1,000 and imprisoned not more than three years.

Fuel Oil Tanks.—Builders of tanks to be installed on passenger vessels for the storage of fuel oil to be used for motive power must make application to the local inspectors of the Steamboat Inspection Service in whose district the installation is to be made and shall submit to said local inspectors blue prints, in triplicate, showing the location of the tanks, pumps, piping, bracing, riveting, etc. The proposed installation as shown on the blue prints must be approved by the supervising inspector in whose district the

installation is to be made. One copy of the blue prints shall be forwarded to the Supervising Inspector General, one retained for the files of the local inspectors, and one copy returned to the party making the installation.

Gas Masks.—All passenger vessels which are provided with sleeping quarters for passengers shall be provided with oxygen-breathing apparatus, and flame safety lamps, as follows:

(a) Vessels with 50 to 100 staterooms for passengers, 4 oxygen-breathing apparatus or 4 gas masks.

(b) Vessels with more than 100 staterooms for passengers, 6 oxygen-breathing apparatus or 6 gas masks and a flame safety lamp.

(c) Oxygen-breathing apparatus or gas masks shall be kept in operative condition and in the following places: Vessels coming under subparagraph (a) 2 shall be in the pilot house, 1 in the engine room, 1 in wireless room. Vessels coming under subparagraph (b) 3 shall be kept in the pilot house, 2 in engine room, 1 in wireless room.

The master and chief engineer shall train a sufficient number of officers and crew in their respective departments in the use of the equipment.

The gas mask mentioned above shall be of an approved type which provides full protection against carbon-monoxide and other gases.

All vessels equipped with refrigeration of any kind shall carry one gas mask of a kind giving protection against the refrigerant used, in addition to the breathing apparatus.

Oxygen-breathing apparatus shall be of at least ½-hour period type, and gas masks shall have the approval of the Board of Supervising Inspectors.

One extra cylinder for each oxygen-breathing apparatus and one extra canister for each gas mask shall be carried.

Gas masks offering protection against refrigerants should be of a type approved by the Bureau of Mines for the service intended.

Gaskets.—(See Hatches.)

Gasoline as Fuel for Auxiliary Plants.—Vessels carrying passengers or freight for hire, permitted under the authority of the Act of Congress approved October 22, 1914, amending Section 4472, Revised Statutes of the United States, to transport and use gasoline or any of the products of petroleum for the operation of engines to supply an auxiliary

lighting and wireless system independent of the vessel's main power plant, shall be allowed to carry such quantities of gasoline or any of the products of petroleum as may be necessary to supply the auxiliary lighting and wireless system when contained in cylindrical tanks constructed in accordance with the rules of the Steamboat Inspection Service: Provided, That in no case shall the quantity of gasoline allowed for this purpose exceed 40 gallons.

Where heavy oils are used in lieu of gasoline, such oils may be carried in quantities not to exceed 15 tons, and must be stored in iron or steel tanks which meet the requirements of rules I and II for unfired pressure vessels, such tanks to be so located that they will not be subject to a temperature greater than 100° F., or properly insulated and vented if this temperature is exceeded.

On all vessels contracted for after July 1, 1935, or where existing installations are replaced, the emergency generator shall be driven by a Diesel or semi-Diesel engine, equipped with approved means for quick starting, such emergency equipment shall be located in steel or iron compartments or rooms on the deck above the weather deck, and isolated from the passenger and crew quarters. Where existing installations of such engines and generators are located in wooden compartments or rooms, such compartments shall be made fire resistant by being lined with asbestos board having a thickness of not less than one-fourth inch, over which iron or steel sheathing shall be fitted.

Two approved fire extinguishers, of either carbon tetrachloride, carbon dioxide, or foam type, shall be permanently located within 5 feet of each tank containing the gasoline, benzine, or naphtha, and in compartments where auxiliary lighting and wireless units are located, 2 fire extinguishers of any of the above-mentioned types shall be placed at the most accessible point.

Gasoline for Motor Lifeboats.—(See Lifeboats.)

Grounding.—(See Accident Reports.)

Gauge.—(See Fire Pumps and Hose.)

Gun.—All ocean vessels shall be equipped with a line-carrying gun and equipment auxiliary thereto, as herein specified.

All coastwise vessels of 150 gross tons and over shall be equipped with a line-carrying gun and equipment auxiliary thereto, as herein specified.

(a) Vessels of 300 gross tons and over shall be equipped

with a mounted-type gun, either breech or muzzle loading; similar in size, performance, and general design to the guns used by the United States Coast Guard.

(b) Vessels under 300 gross tons may use the so-called "shoulder gun," the requirements of which are set forth in a subsequent section under that heading.

The muzzle-loading type of gun shall be of steel or of bronze not less than 20 inches long, 2½ inches smooth bore, and weigh with its carriage not more than 200 pounds. On guns manufactured after June 30, 1920, the primer hole shall be protected by a beading, coaming, or projection extending above the wall of the gun not less than one-half inch. The gun shall be mounted in a carriage on trunnions or other suitable mechanism so as to permit of elevation up to 35°. The carriage may be of wood, reinforced with metal or recesses properly spaced to receive the gun trunnions or other supporting mechanisms. These recesses or seats shall be fitted with detachable trunnion cap squares or a similar device to permit easy mounting and dismounting of the gun. The carriage shall be so constructed that the gun may be secured in elevation. Rings, eyebolts, or other efficient device shall be fitted to the carriage for securing it in position for firing.

(a) The breech-loading type of gun shall be of the materials specified for the muzzle-loading type. It shall also approximate the dimensions and weight required for the muzzle-loading gun and shall be smooth bored. It shall be equipped with suitable breech closing and locking devices, capable or withstanding pressures of 23,500 pounds per square inch. A breech-loading gun must incorporate in its design a suitable gas-checking device to prevent the escape of gas to the rear.

(b) The mount shall be of the slide and carriage type and shall be provided with a suitable recoil-checking mechanism. The slide shall include a means of carrying or mounting the gun so as to permit recoil and the recoil-checking mechanism. It shall be fitted with trunnions which shall rest in the trunnion seats of the carriage so as to permit the gun and slide to be elevated up to 35°. The carriage shall be a U- or a Y- shaped casting having at its base a pivot which will fit in a rail socket or socket stand, thus permitting motion of the gun, slide, and carriage in train. It shall afford suitable trunnion seats fitted with cap squares and bolts. There shall be incorporated in this

type of mount efficient means for securing the gun in elevation and train.

Material used in guns.—(a) Material used in the construction of bronze guns shall have a tensile strength of not less than 65,000 pounds per square inch with an elongation of not less than 20 percent in 2 inches and a reduction of area not less than 25 percent.

(b) Material used in the construction of steel guns shall have a tensile strength of not less than 65,000 pounds per square inch with an elongation of not less than 20 percent in a length of 2 inches.

(c) The manufacturer shall furnish the supervising inspector in whose district the gun is tested a sample of the material used in its construction, accompanied by an affidavit that the specimen submitted actually and correctly represents the material used. The sample shall be distinctly marked with the number appearing on the gun it represents.

Line-carrying gun equipment.—(a) Service projectiles. —Six service projectiles shall be supplied with each gun. These projectiles shall weigh not less than 17 pounds nor more than 18 pounds each. They shall be smoothly turned and finished and shall have a windage of not more than 0.015 nor less than 0.002 of an inch. The upper end shall carry an eyebolt or shank of sufficient length to project slightly beyond the muzzle. This eyebolt or shank shall afford an eye for securing the line. Projectiles shall be of such character as to be readily withdrawn from the gun whenever necessary or desirable.

(b) Service lines.—Four service projectile lines shall be supplied with each gun, and shall be not less than seven-thirty-seconds of an inch nor more than nine thirty-seconds of an inch in diameter, and at least 1,700 feet long. They shall conform to the following requirements:

1. They shall be either 3-strand soft laid best quality flax or regularly laid best quality manila. Each line shall be in one continuous length without splice, knot or other retarding or weakening feature and have a breaking strain of not less than 500 pounds.

2. The end of the line intended to be attached to the projectile shall have securely attached thereto a substantial tag bearing a permanent legend indicating its purpose; the other end of the line shall be tagged in the same manner to prevent delay in securing proper and immediate action with the equipment.

3. Each line shall be coiled, faked, or reeled in its own faking box or reel in such manner that when all the line leaves the container it shall automatically become unattached and free from the container.

(c) Line container.—The faking box or reel shall be of such size as to accommodate the size and type of line used. The faking box shall have a frame slightly larger than the box with a row of wooden pins set vertically into its four sides. It shall have a false bottom which shall be a tablet of wood pierced with holes corresponding to the pins and shall fit down over the pins until it reaches their base and rests on the frame. The frame shall be equipped with proper hooks for securing it to the box after the line has been faked on the pins. The real type container shall consist of a reel upon which the line may be readily coiled and a canister or container into which the coiled line may be placed which will afford a fair lead through which the line may pay out. The reel must be so designed as to permit easy withdrawal after the line has been coiled.

(d) Statement of manufacturer.—The container of the line shall bear the name of the manufacturer and a statement to the effect that in all respects the line meets the requirements specified in paragraph (b), 1, 2, and 3, for service lines.

(e) Primers.—Primers used with the breech-loading gun shall be of the percussion type. Primers used with the muzzle-loading gun shall be of the friction type. At least 25 primers shall be carried at all times.

(f) Auxiliary line.—At least 1,500 feet of 3-inch manila line shall be carried by vessels of over 300 gross tons. This line shall be considered as part of the line-carrying gun equipment, and shall be maintained in first-class condition at all times.

(g) Accessibility.—The line-carrying gun and its equipment shall be kept always easily and immediately accessible and ready for use. No part of this equipment shall be used for any other purpose.

Factory tests.—(a) Tests and approval.—A mounted line-carrying gun shall be tested in the presence of the supervising inspector of the district by firing three rounds from the gun. At least one round shall carry the regular service projectile with one of the service lines attached for a distance of at least 1,400 feet without breaking or fouling the line, under conditions of a reasonably still atmosphere.

The other rounds shall be fired with not less than the same weight powder charge used in the above test, and one shall be fired with not less than an 8-ounce charge. The projectiles used for these shots shall be of the same weight as the service projectile, but no line need be attached. Test shots shall be fired from the gun when mounted on its own carriage, lashed as in shipboard use. After the test has been satisfactorily completed, the gun and carriage shall show no signs of fracture or damage.

(b) Marking of gun and equipment and filing report.—The mounted type line-carrying gun and its equipment, i.e., carriage, line box, or reel and projectiles, shall all bear the same number and be initialed by the inspector who observes the test. He shall file a report of the test, together with the number of the gun, the date, and the result, in the office of the supervising inspector in whose district the test is made, and the supervising inspector shall furnish the manufacturer a copy of the report.

Shoulder gun.—(a) Where allowed.—Vessels of 300 gross tons and under may use the shoulder gun as a means of propelling a line-carrying projectile.

(b) Type.—The shoulder line-carrying gun shall be a breech-loading gun of 0.45 caliber, chambered for blank rifle cartridges, smooth bored and properly stocked. It shall be contained in a suitable case, together with the following equipment: 3 shot lines, 10 projectiles, 25 cartridges, 1 cleaning rod, 1 can of oil, and 1 book of instructions, and conform to the following requirements:

1. The projectiles shall be machined from steel or bronze, weigh about 8 ounces, and have a shank of sufficient length to project slightly beyond the muzzle. The shank shall be made in one with the projectile and have at its upper end an eye for securing the line.

2. The line shall be at least 400 feet in length and have a circumference of about three-eighths of an inch. It shall be woven, or laid up, of cotton or flax and be very flexible, and have a breaking strain of not less than 250 pounds. It shall be made up, or coiled in such way, as to render it ready at all times for immediate use, the coil or other device to permit the free running of the line when the gun is fired.

(c) Auxiliary line.—At least 500 feet of 3-inch manila line shall be carried as an auxiliary line for use with the shoulder line-carrying equipment. This line shall be considered as part of the shoulder gun line-carrying equipment and maintained in first-class condition at all times.

(d) Accessibility.—The shoulder gun line-carrying equipment shall be kept always easily and immediately accessible and ready for use, and no part of this equipment shall be used for any other purpose.

(e) Test.—The projectile shall be thrown, under conditions of a reasonably still atmosphere, for a distance of not less than 250 feet without fouling or breaking the line.

Service recommendations.—(a) Mounted type.—The following precautions and procedure are recommended for the use of mounted type line-carrying guns and equipment:

1. Service powder charge should be about 5 ounces, and the powder bags should be furnished to the vessel containing not more than that quantity of black powder. Under extraordinary circumstances, 8 ounces may be used.

2. In making the line fast to the shank, pass it through the eye and take three or more half-hitches around its own part, leaving a loop of about 10 or 12 inches and taking the hitches about 6 inches apart. This will allow the line to slip slightly through the eye of the shank before the hitches fetch up, thus easing the strain on the line at the loop during the initial acceleration.

3. A considerable bight lead over the side is recommended wherever possible, as it will tend to lessen the jerk on the line at initial acceleration.

4. At least a fathom of the line from the shank should be thoroughly wet before using to prevent burning.

5. The faking box or reel should always be faced in the direction of the line of fire and placed abreast of the gun and as close to the ship's side as possible. It is not advisable to place the line too close to the muzzle of the gun, as the concussion may lift several layers or coils from the top, causing a snarl which in turn may cause the line to part.

6. Care should be taken in placing the equipment to prevent fouling of the line in rigging, ridge ropes, etc., which have a tendency to rise or jump up when the gun is fired.

7. Having made the gun and equipment ready for use, the following procedure in firing is recommended:

Select a place where the gun may recoil without striking anything, or where it may be securely lashed down.

Note the position of the vessel to be relieved, her distance, and the direction and approximate force of the wind, and then place the gun in position, making allowance for the drift of the line. Place the line on the windward side of the gun and about 3 feet from it.

Make the line fast in the eye of the shank and insert the powder charge, projectile, and primer. In loading, make sure that the projectile is seated against the powder charge.

8. After using, the lines should be thoroughly dried before rewinding or faking.

(b) Shoulder type.—In using the shoulder line-throwing type gun, the following precautions should be observed:

1. Care should be taken to prevent fouling of the line in rigging, ridge ropes, etc., which have a tendency to rise or jump up when the gun is fired.

2. The projectile should be seated in the end of the cartridge case.

3. If fired near the ship's side, the gun must be held firmly to prevent it from "jumping" overboard.

4. The line should be wet thoroughly for 2 or 3 feet from the shank to prevent burning.

5. The use of a "reduced load" cartridge is recommended, containing 50 grains of powder instead of 70.

6. After using, the line should be thoroughly dried before rewinding or faking.

7. In using this equipment the instructions furnished by the manufacturer shall be followed.

Drills.—The master of a vessel equipped with a line-carrying gun shall drill his crew in its use and require it to be fired at least once in every 3 months, using one-half the usual charge of powder and any ordinary line of proper length. The service line shall not be used for drill purposes. Each drill shall be recorded in the ship's log book.

On oil tankers and other vessels where a hazard may exist from the actual firing of the gun, the drills shall be carried out and recorded as aforesaid, except that the gun need not be fired.

Placard instructions.—A placard with instructions for using the gun apparatus, as practiced by the United States Coast Guard, shall be posted in the pilot house and engine room, and seamen's, firemen's and steward's departments of every vessel required by law to carry such gun apparatus.

Gun Drills.—(See Drills; Gun.)

Gunpowder.—Upon the application of any master or owner of any steam vessel employed in the carriage of passengers for a license to carry gunpowder, the local inspectors shall examine such vessel, and if they find that she is provided with a chest or safe composed of metal, or

entirely lined and sheathed therewith, or if the vessel has one or more compartments thoroughly lined and sheathed with metal, at a secure distance from any fire, they may grant a certificate to that effect, authorizing such vessel to carry as freight within such chest, safes, or compartments, the article of gunpowder, which certificate shall be kept conspicuously posted on board such vessel.

Hatches.—It shall be the duty of the master of any vessel under the jurisdiction of the Steamboat-Inspection Service to assure himself, before proceeding to sea, that all the cargo hatches of his vessel are properly covered and the covers secured. The covers of all exposed hatches shall be made watertight by the use of pliable gaskets or by heavy canvas tarpaulins, thoroughly covering the hatch cover and firmly secured by iron or steel bars extending from side to side or end to end of the hatchway, which bars shall be securely fastened by toggles or wedges made of hardwood or by the use of efficient screw fastenings. Failure by the master of any vessel to observe this regulation shall be sufficient cause for suspension or revocation of his license on a charge of inattention to his duty.

Hay and Straw.—All hay, straw, or other inflammable material carried on the open deck of any steamer carrying passengers shall be covered with a tarpaulin. (See Cargo and Stores prohibited on passenger steamers.)

Hemp.—No bales of imported or domestic hemp shall be received on any vessel carrying passengers unless the same are properly compressed, bound with rope, wire, or metallic bands, and covered on ends or sides, according to the several methods now practiced in foreign and domestic trade. (See Cargo and Stores prohibited on passenger steamers.)

Hose.—(See Fire Pumps and Hose.)

Hulls.—(See Inspection of Hulls.)

Hydrants.—(See Fire Pumps and Hose.)

Ill Treatment of Crew.—Whoever, being the master or officer of a vessel of the United States, on the high seas, or on any other waters within the admiralty and maritime jurisdiction of the United States, beats, wounds, or without justifiable cause, imprisons any of the crew of such vessels, or withholds from them suitable food and nourishment, or inflicts upon them any cruel and unusual punishment, shall be fined not more than $1,000, or imprisoned not more than five years, or both.

Illegal Boarding of Vessel.—Every person who, not being in the United States service, and not being duly authorized by law for the purpose, goes on board any vessel about to arrive at the place of her destination, before her actual arrival, and before she has been completely moored, without permission of the master, shall, for every such offense, be punishable by a fine of not more than $200, and by imprisonment for not more than six months; and the master of such vessel may take any such person so going on board into custody, and deliver him up forthwith to any constable or police officer, to be by him taken before any justice of the peace, to be dealt with according to the provisions of this Title.

Illegal Shipments (Shanghaiing).—Whoever, with intent that any person shall perform services or labor of any kind on board of any vessel engaged in trade and commerce among the several States or with foreign nations, or on board of any vessel of the United States engaged in navigating the high seas or any navigable water of the United States, shall procure or induce, or attempt to procure or induce, another by force or threats or by representations which he knows or believes to be untrue, or while the person so procured or induced is intoxicated or under the influence of any drug, to go on board of any such vessel, or to sign or in anywise enter into any agreement to go on board of any such vessel to perform service or labor thereon; or whoever shall knowingly detain on board of any such vessel any person so procured or induced to go on board thereof, or to enter into any agreement to go on board thereof, by any means herein defined; or whoever shall knowingly aid or abet in the doing of any of the things herein made unlawful, shall be fined not more than $1,000, or imprisoned not more than one year, or both.

All shipments of seamen made contrary to the provisions of any act of Congress shall be void; and any seaman so shipped may leave the service at any time, and shall be entitled to recover the highest rate of wages of the port from which the seaman was shipped, or the sum agreed to be given him at his shipment.

Illumination for Boat-Launching Operations.—(1) Provision shall be made on all passenger vessels, where the boat deck is more than 30 feet above the water line at the lightest seagoing draft, for readily and continuously available illumination from the vessel of lifeboats when along-

side and in process of or immediately after being launched. There shall be a self-contained source capable of supplying, when necessary, this safety lighting system and placed in the upper part of the vessel above the bulkhead deck.

(2) The emergency generating set will ordinarily provide a satisfactory source of illumination, and, where used for this purpose, it shall be of sufficient power to provide for such illumination in addition to other demands made upon the set.

Inclining Test.—When inspectors have any reason to question the stability of any vessel under their jurisdiction, they shall require the owners of the vessel to make inclining tests on such vessel, under the supervision of the Supervising Inspector General.

On and after July 1, 1924, every passenger or ferry vessel of 500 gross tons or over, propelled by machinery, and every passenger or ferry vessel intended to carry 50 or more passengers, in either case when making application for first inspection to carry passengers, shall be subjected to an inclining test under the supervision of the Supervising Inspector General, and the results of the test shall be approved before the vessel shall be certificated.

The owner or builder of every vessel described in the second paragraph of this section shall, as soon as possible, furnish the local inspectors of the district where the vessel is to be inspected drawings or blue prints, as follows: Sheer, half breadth and body plans, midship section, inboard profile, floors, framing, bulkheads, arrangement of decks and quarters; general arrangement and location of boilers and machinery, plan and elevation; plan and elevation sections through holds, tanks, bunkers, double bottoms, and compartments; and the following curves: Displacement, vertical center of buoyancy, transverse metacenter, longitudinal center of buoyancy, longitudinal metacenter, center of gravity of water planes from either perpendicular, moment to alter trim, and tons per inch; except for double-end ferry-boats, then the drawing or blue print of curves will only be required to show the displacement, vertical center of buoyancy, transverse metacenter, and tons per inch. The drawings and blue prints required by this paragraph shall be forwarded, upon receipt of same, by the local inspectors to the Supervising Inspector General.

Where vessels are required to carry fixed ballast, in order to increase the metacentric height, such ballast shall

not be moved except for examination and repair of vessel, and then only in the presence of an inspector of this service.

The local inspectors shall place a notation in regard to the inclining data on the upper right-hand corner of the certificate of inspection of every vessel subject to this rule, to read as follows: Data relating to the stability of this vessel are on file in the office of the Supervising Inspector General, Washington, D. C.

Increase in Passenger Allowance.—Increases in the passenger allowance of any vessel, whether specified in regular certificate or by excursion permit, may be allowed only after personal inspection of the vessel by the local inspectors, or by the supervising inspector if he grants the increase, who must be satisfied that the vessel and her equipment justify the additional allowance, and of which inspection a written record shall be made and kept in the files of the office granting the allowance and a copy thereof forwarded to the office of the Supervising Inspector General.

Inflammable Articles.—None of the inflammable articles specified under Cargo and Stores prohibited on passenger steamers, or oil that will not stand a fire test of 300° F., shall be used as stores on any pleasure steamer or steamer carrying passengers, except that vessels not carrying passengers for hire may transport gasoline or any of the products of petroleum for use as a source of motive power for the motor boats or launches of such vessels.

Refined petroleum which will not ignite at a temperature of less than 110° F. may, upon routes where there is no other practicable mode of transporting it, be carried on passenger steamers; but it shall not be lawful to receive on board or transport any petroleum unless the owner or master of the steamer shall have first received from the inspectors a permit designating the place or places on such steamer in which the same may be carried or stowed, with the further condition that the permit shall be conspicuously posted on the steamer.

Refined petroleum shall not in any case be received on board or carried unless it is put up in good iron-bound casks or barrels or in good metallic cans or vessels, carefully packed in boxes, and the casks, barrels, or boxes plainly marked on the heads thereof with the shipper's name, the name of the articles, and the degree of temperature (Fahrenheit) at which the petroleum will ignite.

Lubricating oils shall be stored in secure tanks, casks,

or cans in the engine-room compartments or storeroom, or in metal-lined lamp lockers or oil rooms. Kerosene or other illuminating oils meeting the requirements of the law shall be stored in metallic tanks or cans, and carried in the oil rooms or lamp lockers.

Inspection Certificate.—The original certificate of inspection delivered to the master or owner of a steam vessel shall be placed by such master or owner in a conspicuous place in the vessel where it will be most likely to be observed by passengers and others, and there kept at all times, framed under glass, as evidence of the authority thereby conferred: Provided, however, That where it is not practicable to so expose said certificate, it shall be carried in the vessel in such manner as shall be prescribed by the regulations.

Inspection of Hulls.—In the inspection of hulls of vessels, the inspector of hulls shall carefully inspect every accessible part of the hull, and carefully examine the wood or metal of which the hull is constructed, to determine the condition of same, making all necessary hammer tests of hulls constructed of iron or steel. If the inspector shall not have satisfactory evidence otherwise of the soundness of the hull of a wooden vessel, he shall not give a certificate until the same shall be bored or opened up to his satisfaction.

Inspection of Seaworthiness at Domestic Ports.—If the first and second officers under the master or a majority of the crew of any vessel bound on any voyage shall, before the vessel shall have left the harbor, discover that the vessel is too leaky or is otherwise unfit in her crew, body, tackle, apparel, furniture, provisions, or stores to proceed on the intended voyage, and shall require such unfitness to be inquired into, the master shall, upon the request of the first and second officers under the master or such majority of the crew, forthwith apply to the judge of the district court of the judicial district, if he shall there reside, or if not, to some justice of the peace of the city, town, or place for the appointment of surveyors, taking with him two or more of the crew who shall have made such request; and any master refusing or neglecting to comply with these provisions shall be liable to a penalty of $500.

The judge or justice in a domestic port shall, upon such application of the master or commander, issue his precept, directed to three persons in the neighborhood, the most

experienced and skillful in maritime affairs that can be procured; and whenever such complaint is about the provisions, one of such surveyors shall be a physician or a surgeon of the Public Health Service, if such service is established at the place where the complaint is made. It shall be the duty of such surveyors to repair on board such vessel and to examine the same in respect to the defects and insufficiencies complained of and make reports to the judge or justice, as the case may be, in writing, under their hands or the hands of two of them, whether in any or in what respect the vessel is unfit to proceed on the intended voyage, and what addition of men, provisions, or stores, or what repairs or alterations in the body, tackle, or apparel will be necessary; and upon such report the judge or justice shall adjudge and shall indorse on his report his judgment whether the vessel is fit to proceed on the intended voyage, and, if not, whether such repairs can be made or deficiencies supplied where the vessel then lies, or whether it is necessary for her to proceed to the nearest or most convenient place where such repairs can be made or deficiencies supplied; and the master and the crew shall in all things conform to the judgment. The master or commander shall, in the first instance, pay all the costs of such review, report, or judgment, to be taxed and allowed on a fair copy thereof, certified by the judge or justice. But if the complaint of the crew shall appear upon the report and judgment to have been without foundation, the master or commander, or the owner or consignee of such vessel, shall deduct the amount thereof, and of reasonable damages for the detention, to be ascertained by the judge or justice out of the wages of the complaining seamen.

If, after judgment that such vessel is fit to proceed on her intended voyage, or after procuring such men, provisions, stores, repairs, or alterations as may be directed, the seamen, or either of them, shall refuse to proceed on the voyage, he shall forfeit any wages that may be due him.

Inspection of Seaworthiness at Foreign Ports.—Upon a complaint in writing, signed by the first and second officers or a majority of the crew of any vessel, while in a foreign port, that such vessel is in an unsuitable condition to go to sea because she is leaky or insufficiently supplied with sails, rigging, anchors, or any other equipment, or that the crew is insufficient to man her, or that her provisions, stores, and supplies are not or have not been during the voyage suffi-

cient or wholesome, thereupon, in any of these or like cases the consul shall cause to be appointed three persons of like qualifications with those described for domestic ports, who shall proceed to examine into the cause of complaint and who shall proceed and be governed in all their proceedings as provided for domestic ports.

The inspectors appointed by any consul or commercial agent, shall have full power to examine the vessel and whatever is aboard of her, so far as is pertinent to their inquiry, and also to hear and receive any other proofs which the ends of justice may require; and if, upon a view of the whole proceedings, the consul is satisfied therewith, he may approve the whole or any part of the report, and shall certify such approval; or if he dissents, he shall certify his reasons for dissenting.

The inspectors in their report shall also state whether in their opinion the vessel was sent to sea unsuitably provided in any important or essential particular, by neglect or design, or through mistake or accident; and in case it was by neglect or design, and the consular officer approves of such finding, he shall discharge such of the crew as request it, and shall require the payment by the master of one month's wages for each seaman over and above the wages then due, or sufficient money for the return of such of the crew as desire to be discharged to the nearest and most convenient port of the United States, or by furnishing the seamen who so desire to be discharged with employment on a ship agreed to by them. But if in the opinion of the inspectors the defects or deficiencies found to exist have been the result of mistake or accident, and could not, in the exercise of ordinary care, have been known and provided against before the sailing of the vessel, and the master shall in a reasonable time remove or remedy the causes of complaint, then the crew shall remain and discharge their duty.

The master shall pay all such reasonable charges for inspection under such complaint as shall be officially certified to him under the hand of the consul; but in case the inspectors report that the complaint is without any good and sufficient cause the master may retain from the wages of the complainants, in proportion to the pay of each, the amount of such charges, with such reasonable damages for detention on that account as the consul directing the inquiry may officially certify.

Every master who refuses to pay such wages and charges shall be liable to each person injured thereby, in damages, to be recovered in any court of the United States in the district where such delinquent may reside or be found, and in addition thereto be punishable by a fine of $100 for each offense.

Investigation of Accidents.—(See Accident Reports.)

Kerosene.—(See Inflammable Articles.)

Ladders.—Vessels carrying passengers shall be provided with suitable ladders to enable passengers to descend to lifeboats and life rafts, one such ladder being provided for each set of boat davits. These ladders shall be kept ready and convenient for use on the lifeboat deck, and shall reach from such deck to the vessel's light water line. They shall be reversible and free from garment-entangling projections.

Lamp Lockers.—Steam pipes of not less than three-fourths of an inch in diameter shall be led to all lamp lookers, oil rooms, and like compartments, which lamp lockers, oil rooms, and compartments in all classes of vessels, shall be wholly and tightly lined with metal. (See Fire Detecting and Alarm System.)

Lamps.—The use of glass lamps shall be prohibited on any vessel under the jurisdiction of the Steamboat Inspection Service, unless the same are securely fitted into suitable metal brackets.

Lead-ins for Radio.—(See Dangerous Places.)

Licensed Officers.—Every master, chief mate, engineer, and pilot, who receives a license, shall, before entering upon his duties, make oath before one of the inspectors, to be recorded with the certificate, that he will faithfully and honestly, according to his best skill and judgment, without concealment or reservation, perform all the duties required of him by law.

Every applicant for license as either master, mate, pilot, or engineer shall make and subscribe to an oath or affirmation, before one of the inspectors, to the truth of all the statements set forth in his application.

Any person who shall make or subscribe to any oath or affirmation and knowing the same to be false shall be deemed guilty of perjury.

Every licensed officer who shall change, by addition, interpolation, or erasure of any kind, any certificate or license issued by any inspector shall, for every such offense, upon conviction, be punished by a fine of not more than

$500 or by imprisonment at hard labor for a term not exceeding 3 years.

Every licensed officer when employed upon any vessel, within 48 hours after going on duty, place his certificate of license, which shall be framed under glass, in some conspicuous place in such vessel, where it can be seen by passengers and others at all times: Provided, That in case of emergency such officer may be transferred to another vessel of the same owners for a period not exceeding 48 hours without the transfer of his license to such other vessel; and for every neglect to comply with this provision by any licensed officer, he shall be subject to a fine of $100, or to the revocation of his license.

When any licensed officer is employed on a steamer in a district distant from any local board of inspectors, such inspectors may grant a renewal of his license, without such licensed officer being personally present, under such regulations as the board of supervising inspectors shall prescribe.

Licensed officers shall assist the inspectors in their examination of any vessels to which such licensed officers belong and shall point out all defects and imperfections known to them in the hull, equipments, boilers, or machinery of such vessel, and shall also make known to the inspectors at the earliest opportunity all accidents or occurrences producing serious injury to the vessel, her equipments, boilers, or machinery, and in default thereof the license of any such officer so neglecting or refusing shall be suspended or revoked.

No inspector or supervising inspector receiving information from a licensed officer who is employed on any vessel as to defects, shall impart the name of such licensed officer, or the source of his information, to any person other than his superiors in the Steamboat-Inspection Service. Any inspector violating this provision shall be subject to dismissal from the service.

That if any licensed officer shall, to the hindrance of commerce, wrongfully or unreasonably refuse to perform his official duties after having signed articles or while employed on any vessel as authorized by the terms of his certificate of license, or if any pilot or engineer shall refuse to admit into the pilot house or engine room any person whom the master or owner of the vessel may desire to place there for the purpose of learning the profession, his license shall be suspended or revoked.

The local boards of inspectors shall investigate all acts of incompetency or misconduct committed by any licensed officer while acting under the authority of his license, and shall have power to summon before them any witnesses within their respective districts, and compel their attendance by a similar process as in the U. S. circuit or district courts; and they may administer all necessary oaths to any witnesses thus summoned before them; and after reasonable notice in writing, given to the alleged delinquent, of the time and place of such investigation, such witnesses shall be examined, under oath, touching the performance of his duties by any such licensed officer; and if the board shall be satisfied that such licensed officer is incompetent, or has been guilty of misbehavior, negligence, or unskillfulness, or has endangered life, or willfully violated any provision of this Title, they shall immediately suspend or revoke his license.

Every person receiving license or a certificate of lost license shall sign the same and leave a print of his left thumb upon the back thereof, immediately upon its receipt.

Local inspectors will be provided with a blank sheet to be attached to the license when more space is needed for endorsements. This sheet shall be securely glued to the license in a manner so that it may be folded under the license.

The sheet shall bear the signature and thumbprint of the holder as is required for licenses, and shall be inscribed with the words, "Serial Number," "Issue Number," "This license expires ————" (in red ink), as appear on licenses. These data shall be identical with those which appear on the license.

Liens on Vessels.—Any person furnishing repairs, supplies, or other necessaries, including the use of dry dock or marine railway, to a vessel, whether foreign or domestic, upon the order of the owner or owners of such vessel, or of a person by him or them authorized, shall have a maritime lien on the vessel which may be enforced by a proceeding in rem, and it shall not be necessary to allege or prove that credit was given to the vessel.

Lifeboats —(Ocean Steamers.) Under this designation shall be included all steam vessels navigating the waters of any ocean or the Gulf of Mexico more than 20 nautical miles offshore.

Lifeboats.—(Davits Required on Ocean Steamers.) Vessels of classes (*a*) and (*b*) shall be equipped with davits in accordance with the following table:

Registered length of ship in feet	Minimum number of sets of davits	Minimum number of open boats of the first class	Minimum capacity of lifeboats cubic feet
100 and less than 120	2	2	980
120 and less than 140	2	2	1,220
140 and less than 160	2	2	1,550
160 and less than 175	3	3	1,880
175 and less than 190	3	3	2,390
190 and less than 205	4	4	2,740
205 and less than 220	4	4	3,330
220 and less than 230	5	4	3,900
230 and less than 245	5	4	4,560
245 and less than 255	6	5	5,100
255 and less than 270	6	5	5,640
270 and less than 285	7	5	6,190
285 and less than 300	7	5	6,930
300 and less than 315	8	6	7,550
315 and less than 330	8	6	8,290
330 and less than 350	9	7	9,000
350 and less than 370	9	7	9,630
370 and less than 390	10	7	10,650
390 and less than 410	10	7	11,700
410 and less than 435	12	9	13,060
435 and less than 460	12	9	14,430
460 and less than 490	14	10	15,920
490 and less than 520	14	10	17,310
520 and less than 550	16	12	18,720
550 and less than 580	16	12	20,350
580 and less than 610	18	13	21,900
610 and less than 640	18	13	23,700
640 and less than 670	20	14	25,350
670 and less than 700	20	14	27,050
700 and less than 730	22	15	28,560
730 and less than 760	22	15	30,180
760 and less than 790	24	17	32,100
790 and less than 820	24	17	34,350
820 and less than 855	26	18	36,450
855 and less than 890	26	18	38,750
890 and less than 925	28	19	41,000
925 and less than 960	28	19	43,880
960 and less than 995	30	20	46,350
995 and less than 1030	30	20	48,750

(**Coastwise.**) Under this designation shall be included all steam vessels navigating the waters of any ocean or the Gulf of Mexico 20 nautical miles or less offshore.

For the purpose of apportioning lifeboat, life raft, and davit equipment upon ocean and coastwise steam vessels subject to the jurisdiction of the Steamboat-Inspection Service, they shall be divided into the following classes:

(*a*) Passenger steam vessels.

(*b*) Passenger steam vessels the keels of which are laid after July 1, 1915.

(*c*) Cargo steam vessels and all other steam vessels navigating the waters of any ocean, unless hereinafter provided for.

The minimum number of sets of davits is fixed in relation to the length of the vessel; provided that a number of sets of davits greater than the number of boats necessary for the accommodation of all the persons on board may not be required.

Lifeboats.—(Strength and Operation of the Davits.) The davits shall be of such strength that the boats can be lowered with their full complement of persons and equipment, the vessel being assumed to have a list of 15 degrees.

The davits must be fitted with a gear of sufficient power to insure that the boat can be turned out against the maximum list under which the lowering of the boats is possible on the vessel in question.

The Secretary of Commerce is authorized by the seamen's act in specific cases to exempt existing vessels from the requirements of this section that the davits shall be of such strength and shall be fitted with a gear of sufficient power to insure that the boats can be lowered with their full complement of persons and equipment, the vessel being assumed to have a list of 15 degrees, where their strict application would not be practicable or reasonable.

Each set of davits shall have a boat of the first class attached to it, provided that the number of open boats of the first class attached to davits shall not be less than the minimum number fixed by the preceding table.

If it is neither practicable nor reasonable to place on a vessel the minimum number of sets of davits required, a smaller number of sets of davits may be fitted, provided always that this number shall never be less than the minimum number of open boats of the first class required by the table. If a large proportion of the persons on board

is accommodated in boats whose length is greater than 50 feet, a further reduction in the number of sets of davits may be allowed exceptionally, if the arrangements are in all respects satisfactory. Provided, however, That in all cases in which a reduction in the minimum number of sets of davits or other equivalent appliances required by the rules is allowed, the owner of the vessel in question shall be required to prove, by a test made in the presence of an officer designated by the Supervising Inspector General, that all the boats can be efficiently launched in a minimum time.

The conditions of this test shall be as follows:

First: The vessel is to be upright and in smooth water.

Second: The time is the time required from the beginning of the removal of the boat covers, or any other operation necessary to prepare the boats for lowering, until the last boat or pontoon raft is afloat.

Third: The number of men employed in the whole operation must not exceed the total number of boat hands that will be carried on the vessel under normal service conditions.

Fourth: Each boat when being lowered must have on board at least two men and its full equipment as required by the rules.

Fifth: The time allowed for this test shall not exceed 10 minutes.

Vessels of class (*c*) shall be equipped with davits or other practicable means for properly launching the lifeboats.

On passenger vessels, where the height of the boat deck exceeds 20 feet from the lightest seagoing draft, wire falls and mechanical means for lowering shall be provided for each lifeboat. The wire ropes shall be securely attached to the drum of the boat winch. The winch drums are to be arranged to keep the two falls separate, and the lead of the wires shall be such that they will wind evenly on the drums and in such manner that the falls may be paid out at the same rate. Brake gears are to be so arranged that normally they are in the "on" position and return to the "on" position when the handle is not being operated. When more than one lifeboat is served by the same wire falls, the winches shall be fitted with quick return hand gear so that the falls may be rapidly recovered. (Effective on all new passenger vessels immediately and on existing passenger vessels Jan. 1, 1938.)

Lifeboats.—(Lifeboats Required.) (**Oceans.**) Vessels of classes (*a*) and (*b*) shall be equipped with lifeboats in accordance with the preceding table, provided that such vessels shall not be required to carry more lifeboat capacity than is necessary to accommodate all persons on board.

If the lifeboats attached to davits do not provide accommodations for the vessel's actual complement of passengers and crew, additional lifeboats of one of the standard types shall be installed to accommodate all persons on board, or to bring the complement of lifeboat capacity up to the minimum provided by the table, or to 75 percent of the complement of people on board, which ever is the greater.

The remainder of the required equipment shall be provided by lifeboats of one of the standard types or approved life rafts.

On and after January 1, 1936, approved buoyant apparatus sufficient to accommodate 25 percent of all persons on board shall be required in addition to the life-saving equipment specified above. (See Buoyant Apparatus.)

One of the lifeboats on each side of a vessel shall be of suitable size and design for doing emergency work at sea. Each of these boats shall be provided with at least four life lines fitted to a span between the davit heads of sufficient length to reach the water at the vessel's lightest seagoing draft. A releasing gear of the type which may be unhooked under tension is recommended in these boats. A sea painter should be passed along forward on the vessel when at sea and in the lifeboat a long eye, strop, and toggle should be fitted.

The emergency lifeboats required for ocean passenger vessels are held to mean lifeboats of whaleboat or double-ended form of reasonable proportions but not to exceed 60-person capacity.

(**Coastwise.**) Vessels of class (*a*) shall be required to have lifeboat and life raft capacity to accommodate all persons on board. Not less than 75 percent of the total capacity shall be in lifeboats and 25 percent may be in collapsible lifeboats or life rafts of an approved type.

Vessels of class (*a*) during the interval between May 15th and September 15th in any one year, both dates inclusive, shall be required to be equipped with lifeboats, life rafts, and buoyant apparatus to accommodate all persons

on board, not less than 35 percent of which shall be in lifeboats, 35 percent in collapsible lifeboats or life rafts, and 30 percent may be in buoyant apparatus. (Effective on all vessels of class (*a*) Jan. 1, 1936.)

Vessels of class (*b*) shall be required to have lifeboat and life raft capacity to accommodate all persons on board throughout the year, not less than 75 percent of which shall be in collapsible lifeboats or rafts of an approved type.

Vessels of class (*c*) ocean and coastwise.—Cargo vessels shall carry a sufficient number of lifeboats on each side to accommodate all persons on board.

Fishing and wrecking vessels shall carry sufficient lifeboats to accommodate all persons on board, and the following types of boats may be used in lieu of the standard lifeboats.

1. Vessels engaged exclusively in the business of purse seining may use their wooden seine boats.

2. Vessels engaged exclusively in the business of wrecking may use their wooden surf boats.

3. Vessels engaged exclusively in the business of hook-and-line fishing from dories may use their dories when such dories are fitted with air tanks of sufficient capacity to meet the rule for necessary air-tank equipment.

Lifeboats.—(Motor-Propelled Lifeboats.) All ocean steamers of more than 2,500 gross tons carrying passengers, whose route at any point lies more than 200 miles offshore, shall carry at least one motor-propelled lifeboat as a part of their required lifeboat equipment: Provided, That any vessel under the jurisdiction of the Steamboat-Inspection Service may carry one motor-propelled lifeboat as a part of the required lifeboat equipment, but on vessels carrying more than six lifeboats under davits, two of such lifeboats may be motor propelled.

Motor-propelled lifeboats shall comply with the requirements for a lifeboat of class I; and the volume of the internal buoyancy and, where fitted, the external buoyancy shall be increased in sufficient proportion to compensate for the difference between the weight of the motor, the searchlight, and the wireless telegraph installation and their accessories, and the weight of the additional persons which the boat could accommodate if the motor, searchlight, and the wireless telegraph installation and their accessories were removed.

Lifeboats.—(Carrying of Lifeboats on Vessels of Classes

(a) and (b); Ocean and Coastwise.) All vessels of classes (*a*) and (*b*), except those fitted with mechanical davits, shall, when the weather permits, have one of their lifeboats swung out on each side while at sea, brailed into a boom or rail, and ready for immediate use.

Lifeboats.—(Lifeboats Required on Inspected Motor Vessels; Ocean and Coastwise.) All vessels propelled by machinery other than steam, subject to the inspection laws of the United States, shall be required to have the same lifeboat and life-raft equipment as steamers of the same class, and local inspectors shall so indicate in the certificate of inspection.

Motor vessels under 50 tons, when navigating in daylight only, and when equipped with air tanks under deck of sufficient capacity to sustain afloat the vessel when full of water with her full complement of passengers and crew, or when properly subdivided by iron or steel water-tight bulkheads of sufficient strength and so arranged and located that the vessel will remain afloat with her full complement of passengers and crew with any two compartments open to the sea, shall be required to have not less than 100 cubic feet of lifeboat capacity.

Lifeboats.—(Lifeboats and Other Equipment Required on Sailing Vessels.) Sailing vessels carrying passengers on the ocean shall be subject to the same requirements for lifeboat capacity as ocean steamers of the same class, and in addition thereto they shall be equipped with a life preserver for each and every person on board.

Lifeboats.—(Lifeboats and their Equipment Required on Seagoing Barges of 100 Gross Tons and Over.) The lifeboats required on seagoing barges of 100 gross tons or over shall be of an approved type of at least 125 cubic feet capacity.

Equipment required:

Two boat hooks of clear grained white ash of suitable length but not less than 8 feet long by $1\frac{1}{2}$ inches in diameter.

One galvanized-iron bucket of about 2-gallon capacity with lanyard attached.

One life line properly secured the entire length on each side, festooned in bights not longer than 3 feet with a seine float in each bight.

Two life preservers in addition to the vessel's complement of life preservers.

Four oars and one steering oar.

One painter of manila rope not less than $2\frac{3}{4}$ inches in circumference, and of a length not less than three times the distance between the boat deck and the light seagoing draft.

Drain holes, fitted with automatic plugs, shall be provided with two caps attached by chains.

Not less than four rowlocks attached to lifeboat by separate chains.

Lifeboats.—(Equipment for Lifeboats.) Lifeboats, except those hereinafter specified, shall be equipped as follows:

One bailer of sufficient size and suitable for bailing, with lanyard attached.

Two boat hooks of clear grained white ash of suitable length but not less than 8 feet long by $1\frac{1}{2}$ inches in diameter.

One galvanized iron bucket of about 2-gallon capacity, with lanyard attached.

One efficient liquid compass with not less than a 2-inch card.

A watertight metal case containing 12 self-igniting red lights capable of burning and giving forth a brilliant red flame of not less than 500 candlepower for at least 2 minutes. Each distress light shall be treated and made impervious to moisture, and the manufacturer shall place upon it a statement in clear, black letters covering the candlepower and burning range, the directions for firing, the trade name of the distress light, and the name and address of the manufacturer. The container shall be constructed of 18-ounce, or No. 22 B.W.G. copper, or equal noncorrodible metal, lock-jointed and soldered, the bottom to be rolled in and soldered. The cover or top, of cast brass not less than $\frac{1}{8}$-inch in thickness and 5 inches in diameter shall be so constructed as to be easily removed, and made watertight by a fitted rubber gasket.

An approved signal pistol with lanyard attached and 12 red lights, the red light to give forth a brilliant red flame of not less than 30,000 candlepower capacity capable of being projected vertically to a height of not less than 150 feet and of not less than 30 seconds burning duration, the whole to be contained and carried in a portable watertight metal case.

One canvas bag containing sailmaker's palm, needles, sail twine, marline, and marline spike.

Two enameled drinking cups.

One approved flashlight contained in a portable, watertight metal case. The flashlights shall be of all metal,

rugged construction, of focusing type with a reflector head of about 2-inches in diameter.

The batteries for the standard 3-cell type shall be of the sal ammoniac type with depolarizer. They shall have a nonspillable electrolyte and be free from leakage during the useful life of the cell. They shall be of the tubular construction, comprising three cells assembled in line, end to end in a suitable close-fitting tube or jacket of news, chip, or strawboard. The brass cap on the carbon rod and the zinc bottom of the cell shall serve as the terminals. The batteries shall be marked with the "trade name of the cell, the name of the manufacturer or trade mark number, or other designations of size, the date of manufacture, and the date of expiration of a guaranteed period for U. S. Marine Service."

The batteries shall not be continued in use for lifeboat equipment for a period exceeding 1 year from the date of manufacture.

The flashlight batteries allowed under this specification shall be of a quality to meet the National Bureau of Standards tests as to voltage, capacity, delayed service tests, and required performance.

Flashlight containers which conform with the specifications set forth below may be passed by the Local Inspectors without recourse to the Bureau in the same manner that watertight containers for distress lights are passed.

An Executive Committee of the Board of Supervising Inspectors under date of April 25, 1930, ruled that such cases should be constructed of 18-ounce or No. 22 B. W. G. copper, or other non-corrosive metal lock-jointed and soldered, bottom to be rolled in and soldered, cover, or top, to be made of cast brass not less than $\frac{1}{8}''$ thick to fit down on a rubber gasket to make container watertight. The cover shall be so constructed as to be easily removed. Means should be taken to cushion the flashlight and prevent contact with the metal sides of the container.

Two single-edged hatchets attached by lanyards and readily available, one at each end of the boat.

One gallon illuminating oil in metal container.

One lantern containing sufficient oil to burn at least 9 hours and ready for immediate use.

A life line, or grab line, properly secured the entire length on each side, festooned in bights not longer than 3 feet, with a seine float in each bight. The life line shall be

of a size and strength not less than 12-thread manila rope, and the seine float in each bight shall hang to within 12 inches of the surface of the water when the boat is light.

Two life preservers. These life preservers are in addition to the vessel's equipment of life preservers.

A suitable locker or box for the storage and preservation of the small items of equipment.

A mast or masts with at least one good sail, and proper gear for each, the sail and gear to be protected by a suitable canvas cover. Where a vessel carrying passengers in the North Atlantic north of 35° north latitude, is provided with a radiotelegraph installation, only one of the lifeboats on each side of the vessel shall be required to be so equipped. Motor life boats are exempted from this requirement.

One box of friction matches in a watertight container, and carried in a box secured to the underside of the stern thwart, or stowed in locker.

A single banked complement of oars, two spare oars, and a steering oar with rowlock or becket conforming to the following requirements:

Minimum number and lengths of oars

Length of boat	Number oars	Spare oars	Total, including steering oar	Rowing oars	Steering oars
				Feet	*Feet*
16 feet and under 18 feet	4	2	7	10	12
18 feet and under 20 feet	4	2	7	11	13
20 feet and under 24 feet	4	2	7	13	14
24 feet and under 28 feet	6	2	9	14	15
28 feet and over	6	2	9	15	16

NOTE.— Motor lifeboats and lifeboats fitted with propellers operated by hand shall be equipped with 4 oars and 1 steering oar.

One painter of manila rope not less than $2\frac{3}{4}$ inches in circumference and a length not less than three times the distance between the boat deck and the light draft.

Drain holes, fitted with automatic plugs, shall be provided with two caps attached by chains. Decked lifeboats shall have no plug-hole, but shall be provided with at least two bilge pumps.

Lifeboats may be fitted with a hand-operated propeller of an approved type, but all lifeboats, except motor boats, having a capacity of 60 or more persons, shall be fitted with a hand-operated propeller of an approved type.

The hand-propelling gear shall be substantially constructed and fitted in the boat in an efficient manner and be such that the boat may be readily maneuvered away from the ship's side after being launched and steerageway maintained, under adverse weather conditions. The gear shall be of such character that it may be operated by persons untrained in its use. It shall be such that it can be operated satisfactorily when the boat is partially flooded and will be effective in propelling a boat fully or partially loaded.

The above propelling gear shall be required in all such lifeboats fitted on new vessels and to the lifeboat replacements on existing vessels.

An airtight receptacle containing 2 pounds of provisions for each person. These provisions may be of hard bread or its equivalent in any approved emergency ration of cereal or vegetable compound. No meat or other ration requiring saline preservative shall be allowed. The receptacle shall be of metal fitted with an opening in the top not less than 5 inches in diameter properly protected by a screw cap made of heavy cast brass with machine thread and an attached double toggle, seating to a pliable rubber or felt gasket, which shall insure a tight joint.

One set and a half of thole pins or rowlocks attached to the lifeboat by separate chains.

One rudder having either tiller or yoke and yoke lines. The rudder shall be made of clear straight-grained oak or fir and shall be stiffened across the bottom edge by a piece of wood of the same character, properly secured. Pintles shall be strapped to the wood and through fastened and be so adjusted that the lower pintle will project at least $1\frac{1}{2}$ inches more below its gudgeon than does the upper one.

One sea anchor constructed of good quality canvas or other satisfactory material; and, if of circular pattern, shall be not less than 2 feet in diameter for lifeboats 26 feet long and under. In larger boats the diameter of the sea anchor shall be not less than 2 feet 6 inches.

One container holding 1 gallon of vegetable or animal oil, so constructed that the oil can be easily distributed on the water and so arranged that it can be attached to the sea anchor.

Wooden breakers or suitable tanks fitted with spigots for drawing water and containing at least 1 quart of water for each person.

Lifeboats.—(**Equipment for Lifeboats.**) Coastwise vessels to be equipped as above.

Lifeboats.—(**Equipment for Motor Lifeboats.**) In addition the equipment required above, motor lifeboats shall carry 2 fire extinguishers of the carbon tetrachloride type, but need not carry a mast or sails nor more than 4 rowing oars and 1 steering oar. At least one motor lifeboat shall be fitted with a wireless installation and a searchlight.

Motor and Accessories.—The engine for motor-propelled lifeboats shall be of a reliable slow-speed heavy-duty type, permanently installed inside the lifeboat.

The power of motor lifeboats shall be such that the speed through the water, in smooth water, shall be at least 6 knots when fully loaded. Under these conditions, fuel capacity sufficient for 24 hours' continuous operation shall be provided.

Suitable provision shall be made for going astern.

The motor shall be protected by a weatherproof enclosure. The top of the enclosure shall be constructed so that it may be removed when necessary and shall be fitted with a ventilator of a water-protector type.

Fittings, pipes, and connections shall be of high standard and good workmanship and installed in accordance with good practice. There shall be a strainer between carburetor and fuel tank and an efficient hand starter.

The motor of each lifeboat shall be operated ahead and astern for a period of not less than 5 minutes at least once in every 7 days to test its readiness for service, such operation to be part of the lifeboat drill and included in the report of such drill.

The fuel shall be stored in substantial tanks of seamless steel, welded steel or copper firmly secured inside the lifeboat and suitably located. The fuel tank should be emptied and fuel changed at least once a year. The storage of fuel outside the lifeboat using it is prohibited.

Motor boats certified for 100 or more persons shall be fitted with at least two bilge pumps, one of which shall be an efficient hand pump. The bilge pumps are each to be capable of pumping from each compartment. Motor boats certified for less than 100 persons shall be fitted with a bilge pump, either hand or power, having suitable suctions or drainage to different parts of the boat.

Searchlight.—The searchlight for use on motor lifeboats shall include a lamp of at least 80 watts, an efficient re-

flector, and a source of power which will give effective illumination of a light-colored object over a width of about 60 feet at a distance of 200 yards intermittently for a period of 6 hours, and continuously for a period of 3 hours.

Wireless telegraph installation.—The wireless telegraph installation shall be of a type capable of transmitting clearly perceptible audible signals between lifeboat and vessel on the international calling and distress frequency, and a radio receiving equipment capable of satisfactorily receiving such signals. The range shall be not less than 50 nautical miles by day across the sea under normal conditions and circumstances. The power supply shall be capable of operating this equipment for a continuous period of at least 6 hours.

Motor lifeboats which are carried on vessels that do not go more than 200 miles from shore and motor lifeboats carried in excess of those required need not be equipped with a radio installation nor a searchlight.

Where the power is derived from one source for both the wireless and the searchlight, it shall be ample to provide for the efficient working of both appliances.

Lifeboats.—(**Air Tanks of Lifeboats.**) All lifeboats contracted for after September 30, 1912, shall have not more than 50 per cent of the air-tank capacity in the ends of the boat and the remaining capacity shall be located in the side tanks.

After June 20, 1912, the air tanks of all lifeboats shall be entirely independent of the hull or other construction and shall be of suitable noncorrosive material and of a capacity of not less than 1.5 cubic feet for each person allowed in metallic boats and not less than 1 cubic foot for each person allowed in wooden boats. Such air tanks shall be firmly and securely fastened in the hull, and in such manner as will allow them to be temporarily removed, and in no case shall the tanks be punctured or opened for such fastenings. The tops of such tanks shall be thoroughly protected by a grating or platform or by the thwarts or seats. Such air tanks of 6 cubic feet or less shall be constructed of material of a thickness not less than No. 22 B. W. G.; from 6 cubic feet to and including 15 cubic feet, of a thickness not less than No. 20 B.W.G.; and all air tanks of more than 15 cubic feet capacity shall be of a thickness not less than No. 18 B. W. G.

All joints of air tanks shall be properly double riveted

and tightly calked or securely hook jointed and efficiently soldered or properly and securely welded, and such air tanks shall be located in such a manner that will permit the lifeboat to be on as near an even keel as possible when flooded with water.

The cubical contents of air space of air tank shall be stamped on the tank where same can be seen when air tank is placed in boat.

All air tanks shall be fitted with a connection of one-half inch outside diameter for testing purposes.

Before any lifeboat is passed and accepted, the air tanks thereof shall be tested in the presence of an inspector of this service by an air-pressure of not more than 1 pound to the square inch. At each subsequent annual inspection, or oftener if in the opinion of the inspectors it is necessary or desirable, the inspectors shall satisfy themselves that the tanks are in good condition, but pressure need not be applied unless the inspectors are in doubt regarding the efficiency of the tanks. This does not take from the inspectors the right and authority to satisfy themselves at any time, either by examination or pressure, as to the condition of the tanks.

Lifeboats.—(Cubic Capacity of Open Boats.) The following rule may be used: Measure the length and breadth outside of the planking or plating and the depth inside at the place of minimum depth. The depth used in calculating shall not in any case exceed 45 per cent of the breadth. The product of these dimensions multiplied by 0.6 resulting in the nearest whole number shall be deemed the capacity in cubic feet.

To determine the number of persons a boat may carry, divide the result by 10 for ocean steam vessels.

Example.—The carrying capacity of a boat 22 feet in length, 6 feet in breadth and $2\frac{1}{2}$ feet in depth shall be determined as follows:

$$\frac{22 \times 6 \times 2.5 \times 0.6}{10} = \frac{198}{10} = 19 \text{ persons.}$$

In all cases the vessel owner has the right to require that the cubic capacity of the boat shall be determined by exact measurement.

The cubical capacity of a motor boat shall be obtained by deducting from the gross capacity a volume equal to that occupied by the motor and its accessories, and, when

carried, the wireless installation and searchlight with their accessories.

The cubical capacity of a lifeboat propelled by hand-operated propeller shall be obtained by deducting from the gross capacity a volume equal to that occupied by such device.

When computing the air tank requirements, the weight of the motor and its accessories, and, when carried, the wireless installation and searchlight with their accessories, shall be carefully considered in the calculation and allowance made for the extra buoyancy required for such weight.

Lifeboats.—(Marking of Lifeboats.) The number of each lifeboat shall be plainly marked or painted on each side of the bow in figures 3 inches high; and, where lifeboats are carried on both sides of a vessel, the odd-numbered boats shall be stowed on the starboard side and the even-numbered boats on the port side; i.e., lifeboat No. 1 shall be forward on the starboard side, and lifeboat No. 3 next abaft lifeboat No. 1; lifeboat No. 2 shall be forward on the port side and lifeboat No. 4 next abaft lifeboat No. 2, etc. Where lifeboats are nested the lifeboat under lifeboat No. 2 shall be numbered 2A, etc.

The cubical contents and number of persons allowed to be carried on each lifeboat shall be plainly marked or painted on each side of the bow in letters and numbers $1\frac{1}{2}$ inches high. In addition, the number of persons allowed shall be plainly marked or painted on the top of at least two of the thwarts in letters and numbers 3 inches high. Such letters and numbers shall be dark on a light ground or light on a dark ground.

Lifeboats.—(Lifeboats and Life Rafts Kept Clear for Launching.) The decks on which lifeboats of any class or life rafts are carried shall be kept clear of freight or any other obstruction that would interfere with the immediate launching of the lifeboats or life rafts.

Lifeboats.—(Boat-Davit Falls and Receptacles Therefor.) It shall be the duty of the master or officer in charge of all vessels to see that the boat-davit falls shall at all times be in readiness for immediate use, and protected from ice, and not painted, and such boat-davit falls on all boats not swung out at boat drills shall be cast loose and overhauled; and it shall be unlawful to stow in any lifeboat articles other than those required by law and regulations. On all steamers over 1,000 gross tons, covered tubs,

boxes, or reels shall be provided in which to stow away the boat-davit falls.

Where more than one lifeboat is served under one set of davits, means shall be provided that will prevent davit tackles from twisting or capsizing, and that will permit the tackles being readily rounded up for the purpose of launching the remaining lifeboats under such davits: Provided, That when davits are equipped with separate tackles for each boat, such non-twisting and non-capsizing device is not required.

Lifeboats.—(Care of Lifeboats.) Lifeboats shall be stripped, cleaned, thoroughly overhauled, and painted at least once in every year.

Lifeboats.—(Test of Boats at Annual Inspection.) The inspectors shall satisfy themselves that every lifeboat, together with its equipment, of all vessels is in every respect in good condition and ready for immediate use.

Every lifeboat, with its required equipment, of passenger vessels shall be lowered to near the water and loaded to its allowed capacity, evenly distributed throughout its length, and then lowered into the water afloat. In making this test persons or dead weight may be used; if persons are used, the weight of each person shall average at least 140 pounds. When dead weight is used, the weight shall be equivalent to at least 140 pounds for each person allowed.

Lifeboats.—(Size of Boats.) No lifeboat for use on ocean steam vessels shall be of less than 180 cubic feet capacity, except that all pleasure steamers and other steamers not exceeding 1,000 gross tons limited by their certificate of inspection to routes not exceeding 20 nautical miles offshore shall only be required to carry one lifeboat of 180 cubic feet capacity. Nothing, however, shall exempt such steamers from carrying the aggregate cubic capacity required by the rules. The minimum capacity of lifeboats for this class of vessels shall be 125 cubic feet.

The supervising inspector of the district may, in exceptional cases, permit lifeboats of less than 180 cubic feet as a substitute for said boat on steamers where the crew is insufficient to properly carry so large a lifeboat, but in every such case the steamer shall be provided with one or more lifeboats efficient in character and large enough to carry every person on board, and in no case shall the lifeboat be of less capacity than 125 cubic feet.

Lifeboats.—(Handling of the Boats and Rafts.) All

the boats and rafts must be stowed in such a way that they can be launched in the shortest possible time and that, even under unfavorable conditions of list and trim from the point of view of the handling of the boats and rafts, it may be possible to embark in them as large a number of persons as possible.

The arrangements must be such that it may be possible to launch on either side of the vessel as large a number of boats and rafts as possible.

Where practicable, lifeboat chocks on passenger vessels shall be so fitted that the lifeboats they serve shall not require lifting before launching.

At least once in each interval of not longer than three months the master of every inspected passenger vessel shall drill and exercise every member of the crew, except females, in pulling oars in the ship's lifeboats.

In addition, the crew of the motor-propelled boats shall demonstrate their ability in the working of the engine and handling of the boat under power.

Lifeboats.—(Certificated Lifeboat Men.) There shall be for each boat or raft a number of lifeboat men at least equal to that specified as follows: If the boat or raft carries 25 persons or less, the minimum number of certificated lifeboat men shall be 1; 26 persons and less than 41 persons, lifeboat men 2; 41 and less than 61 persons, lifeboat men 3; 61 to 85 persons, lifeboat men 4; 86 to 110 persons, lifeboat men 5; 111 to 160 persons, lifeboat men 6; 161 to 210 persons, lifeboat men 7; and, thereafter, 1 additional certificated lifeboat man for each additional 50 persons: Provided, That if the raft carries 15 persons or less a licensed officer or able seaman need not be placed in charge of such raft: Provided further, That one-half the number of rafts carried shall have a capacity of exceeding 15 persons.

The allocation of the certificated lifeboat men to each boat and raft remains within the discretion of the master, according to the circumstances.

By "certificated lifeboat man" is meant any member of the crew who holds a certificate of efficiency issued under the authority of the Secretary of Commerce.

An applicant for certificate as lifeboat man shall be eligible for examination after he has furnished satisfactory evidence to the examiner that he has had the following experience: Not less than 12 months' sea service in the deck

department; or, not less than 24 months' sea service in other departments. Sea service means actual experience on board vessels in ocean, lake, bay, or sound service.

Before a lifeboat man's certificate may be granted the applicant must prove to the satisfaction of the examiner that he has been trained in all the operations connected with launching lifeboats and life rafts and the use of oars, and sail; that he is acquainted with the practical handling of the boats themselves; and, further, that he is capable of understanding and answering the orders relative to lifeboat service.

The oral examination shall consist of questions regarding the construction of lifeboats and life rafts, the names of their different parts, and a description of the equipment required, the construction and functions of the gravity, radial, and round-bar types of davits; clearing away, swinging out, and lowering boats and rafts; handling boats under oars and sail; and nautical terms used in connection with launching and handling lifeboats.

The practical examination shall consist of a demonstration of the applicant's ability to carry out the orders incident to launching lifeboats, and the use of the boat's sail, and to row.

The certificate, Bureau record, and the stub shall bear an imprint of the left thumb of the holder on the back thereof.

Lifeboats.—(Manning of Boats.) A licensed officer or able seaman shall be placed in charge of each boat or pontoon raft; he shall have a list of its lifeboat men and other members of its crew which shall be sufficient for her safe management, and shall see that the men placed under his orders are acquainted with their several duties and stations.

A man capable of working the motor shall be assigned to each motor boat.

The duty of seeing that the boats, pontoon rafts, and other life-saving appliances are at all times ready for use shall be assigned to one or more officers.

Life Buoys.—

All life buoys and water lights shall be distributed and secured as follows:

1. All life buoys shall be so placed as to be readily accessible to the persons on board, and their positions plainly indicated so as to be known to the persons concerned.

Number required.—The minimum number of life buoys and the minimum number to which water lights shall be attached is fixed by the following table:

Length of vessel	Minimum number of buoys	Minimum number of buoys to which water lights shall be attached
Under 200 feet	8	6
200 feet and under 400 feet	12	6
400 feet and under 600 feet	18	9
600 feet and under 800 feet	24	12
800 feet and over	30	15

One life buoy on each side of a vessel shall have an attached line at least 15 fathoms in length.

2. The buoys shall always be capable of being cast loose, and shall not be permanently secured in any way.

3. On oil tank vessels the self-igniting water lights need not be attached to the ring buoy, but may be placed alongside the buoy which it is intended to serve so that it can be easily and quickly attached to the buoy by means of its lanyard when needed in case of emergency. When self-igniting water lights are not attached to the ring buoys, a snap hook shall be provided for this purpose.

Buoyancy.—Life buoys shall be capable of sustaining in fresh water for a continuous period of 24 hours an attached weight so arranged that whether said weight be submerged or not there shall be a direct downward gravitation pull upon the buoy of not less than 32 pounds. The required buoyancy may be supplied by solid cork or any other equivalent material, but no life buoy shall be approved which is filled with rushes, cork shavings or granulated cork, or any other loose granulated material, or whose buoyancy depends upon air compartments which require to be inflated.

Standard ring life buoys.—Ring buoys of the standard type shall be of not less than 30 inches outside diameter and not less than 17 inches inside diameter, but any form of construction which will meet the general purposes of this specification may be used after having been approved by the Board of Supervising Inspectors.

Buoyant material.—The buoyant material shall be of sheet cork weighing not more than 12 pounds per cubic

foot. The cork shall be in two layers or thicknesses. The cork sheets shall be flattened and smoothed so that the back or outside hard crust is removed sufficiently to give a smooth surface for gluing. One layer shall be built of segments not to exceed four in number. The other layer may be built of segments not to exceed eight in number. The ends of all segments shall be fitted neatly and glued securely one to the other. The two layers shall be neatly jointed and properly and securely dowel-pinned and glued firmly together, with joints staggered or broken. When completed, the outside of the life buoy shall be of good, sound corkwood finished to a smooth surface.

Glue.—The glue used shall be insoluble in water, and the finished life buoy shall stand steaming at a pressure of two pounds for a period of 30 minutes without disintegration or other positive indications of the glue losing its adhesive properties.

Strength.—The body of the life buoy before covering shall withstand a downward gravity pull of 200 pounds, the weight to be attached to the life buoy body by a sling covering a surface of 2 linear inches without breaking, without rupture of the joints, or without showing a maximum elongation of internal diameter in excess of $1\frac{1}{2}$ inches while the weight is attached and after being under this test for a period of 30 minutes.

Covering.—The life buoy shall be covered with cloth of sufficient weight and strength to protect fully the body of the life buoy, such material to be a strength at least equal to unbleached single-filling cotton duck having a weight of 10 ounces per square yard.

Sewing.—The cover shall be constructed and placed on the body of the life buoy in a substantial manner. All seams and other machine sewing on the life buoy shall be with a short lock stitch not less than eight stitches to the inch. The inside seam shall be sewed with a rope stitch not less than three stitches to the inch. All thread used in the construction of the life buoy shall be No. 16, three-cord linen.

Beckets.—Four beckets $2\frac{1}{2}$ inches wide, made from the same material as the covering of the buoy, shall be securely attached to the life buoy and spaced an equal distance from each other.

Grab line.—A grab line shall pass through the beckets which shall be sewed tightly together to prevent slipping.

The line shall be manila, $\frac{3}{8}$-inch in diameter, three-ply, medium quality, having the ends securely and neatly spliced, the line to be festooned in bights around the outer edge of the life buoy.

Factory inspection of life buoys.—The supervising inspector of the district shall detail a local or assistant inspector to any place where ring life buoys are manufactured within his district, whose duty it shall be to test and examine all such buoys manufactured at that place. When a ring life buoy is found to be in accordance with the requirements of the rules of the Board of Supervising Inspectors the inspector shall stamp the buoyant material, and, after completion of the buoy, shall stamp the cover with the word "Passed," his initials, the inspection port, and the date of approval. The buoyant material and the cover shall also be stamped by the manufacturer with the name or trade mark of the manufacturer.

Luminous buoys are those having attached an efficient self-igniting light which cannot be extinguished in water.

Life Preservers.—Every vessel shall be provided with one good life preserver, having the approval of the Board of Supervising Inspectors, for each and every person carried, and every vessel carrying passengers shall have in addition thereto a number of life preservers suitable for children equal to at least 10 per cent of the total number of persons carried.

Every life preserver adjustable to the body of an adult person, manufactured after February 10, 1923, shall be of the reversible type, made of suitable material approved by the Board of Supervising Inspectors, with straps properly attached on each side of the body of the life preserver (thus making it reversible), with recesses under the arms, thereby allowing the front and back sections to fit around the upper part of the wearer, and held in place by the straps, and the upper part of the life preserver shall be made vestlike cut so as to fit snugly over the shoulders, the whole so constructed as to place the main buoyant body of the device underneath the shoulders and around the body in a manner that it will support the person wearing it in an upright or a slightly backward position.

All such life preservers shall be not less than 52 inches in length when measured laid flat, and every life preserver shall be capable of sustaining for a continuous period of at least 24 hours an attached weight so arranged that whether

the said weight be submerged or not there shall be a direct downward gravitation pull upon said life preserver of at least 20 pounds.

All life preservers shall be covered with unbleached, uncolored, or chrome yellow (vat dye) cotton drill or twill without filling or sizing, weighing not less than 7.2 ounces to the square yard, except that vivatex or its equivalent may be used where it is of a weight not less than 10.2 ounces for each square yard. The covering shall be in not more than 2 pieces, 1 piece forming either side. The lower longitudinal edge of the covering seam shall be turned to a roll and closely rope stitched.

The straps or other approved means of securing the life preservers about the body of the wearer shall be of double-woven cotton tape of 1¼ inches width with two selvage or cord edges, of 175 pounds tensile strength, extending along both sides of the life preserver and secured thereto in a permanent manner, so as to make such life preserver reversible, the ends of the straps extending 12 inches beyond the ends of the jacket: Provided, That when it becomes necessary to replace belt straps on life preservers of the single belt type, it shall be done in the foregoing manner, so as to make such repaired life preservers reversible.

Inspectors are required to direct such life preservers to be distributed throughout the cabins, staterooms, berths, and other places convenient for passengers on such steamers, and there shall be a printed notice posted in every cabin and stateroom and in conspicuous places about the deck informing passengers of the location of life preservers and of the mode of applying or adjusting the same. Life preservers on passenger, excursion, and ferry steamers when stowed overhead shall be so supported that they can be quickly released and distributed among the passengers, and the inspector shall satisfy himself as to the efficiency of the means used for such purpose by actual experiment; and when such life preservers are stowed overhead at a height greater than 7 feet from the deck below efficient means shall be provided for such immediate release and distribution to be operated by persons standing on the deck below.

Each life preserver shall be marked on the front compartment "Adults," if for the use of adults; and "Children," if for the use of children; and if of a character suitable for the use of both adults and children, it shall be so marked.

Life Preserver Drills.—(See Emergency Signals.)

Life Rafts.—(Tests of Air Tanks.) Before any life raft is passed and accepted, the air tanks thereof shall be tested in the presence of an inspector by an air pressure of not more than 1 pound to the square inch. At each subsequent annual inspection, or oftener, if in the opinion of the inspectors it is necessary or desirable, the inspectors shall satisfy themselves that the tanks are in good condition, but pressure need not be applied unless the inspectors are in doubt regarding the efficiency of the tanks. This does not take from the inspectors the right and authority to satisfy themselves at any time, either by examination or pressure, as to the condition of the tanks.

Life Rafts.—(Care of the Life Rafts.) All life rafts shall be stripped, cleaned, painted, and thoroughly overhauled at least once in every year, and inspectors shall carefully examine at all inspections the material which supports the platform of all life floats in order to determine to their satisfaction that the strength is maintained. If it is found that deterioration has begun it shall be corrected even to the extent of requiring the renewal of the platform-supporting device.

Life Rafts.—(Capacity and Allowance.) No type of raft may be approved unless it satisfies the following conditions:

1. It should be reversible and fitted with bulwarks of wood, canvas, or other suitable material on both sides. These bulwarks may be collapsible and shall be not less than 4 inches high.

2. It should be of such size, strength, and weight that it can be handled without mechanical appliances, and, if necessary, be thrown from the vessel's deck.

3. It should have not less than 3 cubic feet of air cases or equivalent buoyancy for each person whom it can accommodate.

4. It should have a deck area of not less than 4 square feet for each person whom it can accommodate, and the platform should be not less than 6 inches above the water level when the raft is loaded.

5. The air tanks or equivalent buoyancy should be placed as near as possible to the sides of the raft.

Rafts shall never be allowed a greater number of persons than for which there is proper seating capacity without interfering with the use of the oars. At least one-half of the number of life rafts on all steam vessels shall each have a capacity exceeding 15 persons.

Life Rafts.—(Drawings, Specifications, Name Plate, and How Marked.) All life rafts shall be substantially constructed in accordance with drawings, or blueprints, and specifications approved by the Board of Supervising Inspectors.

Builders of life rafts shall furnish the supervising inspector of the district in which the life rafts are built drawings, or blue prints, and specifications, showing and explaining the construction of same and showing the tensile strength and ductility of the metal used. Life rafts may be constructed of steel having a minimum tensile strength not less than 50,000 pounds per square inch and an elongation of at least 20 percent in a gage length of 8 inches; or of wrought iron having a minimum tensile strength of 45,000 pounds per square inch and a minimum elongation of 12 percent in 8 inches; or of other approved metals. Where steel is used and a minimum thickness of the metal is less than No. 16 B. W. G., the elongation shall not be less than 15 percent in a gage length of 8 inches.

Builders of life rafts shall affix a plate or other device to each life raft, having thereon the builder's name, number of raft, date of construction of raft, cubical contents of raft, and number of persons said raft will carry, as determined by the rules of the Board of Supervising Inspectors.

There shall be stenciled in a conspicuous place on each life raft now in use the number of persons said raft can carry.

Life Rafts.—(Construction of Rafts of the Catamaran Type.) All metal life raft cylinders of more than 15 feet in length or of more than 16 inches in diameter shall be constructed of metal not less than No. 18 B. W. G. No life raft cylinders shall be of less thickness of metal than No. 20 B. W. G.

The retaining bands which secure the cylinders to the frames shall be made in halves, so that the cylinders may be detached without difficulty and without disassembling the body of the raft, for the purpose of inspection, cleaning, and painting. Wooden guards and gunwales shall be secured to the retaining bands by angle-iron clips or by the jaws of the retaining bands. Iron rods extending across the raft at top and bottom shall pass through the gunwales and its securing clips or jaws at each end of the raft. The ends of the rods shall be properly secured with a screw nut inside and outside of the gunwale.

All such cylinders shall be divided by water-tight bulkheads into not less than three compartments of equal lengths. Cylinders over 9 feet in length shall be divided into equal lengths by water-tight bulkheads into not less than one compartment for every 3 feet of its length. One of such bulkheads shall be at the extreme end of each cylinder or as near thereto as the flange of cone of bumped ends will permit. Each compartment shall be provided with a suitable air pump connection of ½ inch outside diameter, fitted with air-tight cap.

Only countersunk-headed rivets shall be used in the construction of metallic life rafts.

All seams and joints shall be properly double riveted.

The above provisions of this section shall take effect only as to life rafts constructed after December 31, 1908.

The circumferential as well as the longitudinal seams of life raft cylinders shall be riveted and tightly calked, or securely hook jointed and efficiently soldered, or properly and securely welded on rafts constructed after June 30, 1905. Such longitudinal seams shall be secured by not less than 12 rivets to each foot, circumferential seams by not less than 10 rivets to each foot, and bulkheads by not less than 8 rivets to each foot. Bulkhead flanges may be single riveted. The diameter of shank of rivets shall be not less than No. 10 B. W. G.

The framework connecting the cylinders of metallic life rafts shall be substantially built and capable of resisting the strain which tends to break the cylinders apart when the raft is broadside on in surf or seaway.

Life Rafts.—(**Handling.**) All rafts must be stowed in such a way that they can be launched in the shortest possible time and that, even under unfavorable conditions of list and trim from the point of view of the handling of the rafts, it may be possible to embark in them as large a number of persons as possible.

The arrangement must be such that it may be possible to launch on either side of the vessel as large a number of rafts as possible.

Life Rafts.—(**Equipment.**) All life rafts on ocean steam vessels shall be equipped as follows:

Distress signals.—One water-tight metal case containing 12 self-igniting red lights of same character as distress lights required for lifeboats, the container to be of the same material and construction as required for lifeboats.

Drinking Cups.—Two enameled drinking cups.

Life line.—One life line properly secured entirely around the sides and ends of the raft, festooned to the gunwales in bights not longer than 3 feet with seine float in each bight.

Matches.—One box of friction matches in a water-tight container.

Oars.—Four oars.

Painter.—One painter of manila rope not less than $2\frac{3}{4}$ inches in circumference and a length not less than 3 times the distance between the boat deck and the light draft.

Provisions.—One air-tight receptacle containing 2 pounds of provisions for each person. These provisions may be of hard bread or its equivalent in any approved emergency ration of cereal or vegetable compound. No meat or other ration requiring saline preservative shall be allowed. The receptacle shall be of metal fitted with an opening in the top not less than 5 inches in diameter properly protected by a screw cap made of heavy cast brass with machine thread and an attached double toggle, seating to a pliable rubber or felt gasket, which shall insure a tight joint.

Rowlocks.—Five rowlocks attached by separate chains.

Sea anchor.—One sea anchor constructed of good quality canvas or other satisfactory material; and, if of circular pattern, shall be not less than 2 feet in diameter.

Self-igniting water light.—One self-igniting water light of approved type.

Storm oil.—One container holding one gallon of vegetable or animal oil so constructed that the oil can be easily distributed on the water, and so arranged that it can be attached to the sea anchor.

Water.—One water-tight receptacle containing 1 quart of water for each person.

Lights, Distress.—(See lifeboat equipment.)

Line Carrying Gun.—(See Gun.)

Log Book, Official.—Every vessel making voyages from a port in the United States to any foreign port, or being of the burden of 75 tons, or upward, from a port on the Atlantic to a port on the Pacific, or vice versa, shall have an official log book; and every master of such vessel shall make, or cause to be made therein, entries of the following matters, that is to say:

1. Every legal conviction of any member of his crew, and the punishment inflicted.

2. Every offense committed by any member of his crew for which it is intended to prosecute, or to enforce a forfeiture, together with such statement concerning the reading over such entry, and concerning the reply, if any, made to the charge.

3. Every offense for which punishment is inflicted on board, and the punishment inflicted.

4. A statement of the conduct, character, and qualifications of each of his crew; or a statement that he declines to give an opinion of such particulars.

5. Every case of illness or injury happening to any member of the crew, with the nature thereof, and the medical treatment.

6. Every case of death happening on board, with the cause thereof.

7. Every birth happening on board, with the sex of the infant, and the names of the parents.

8. Every marriage taking place on board, with the names and ages of the parties.

9. The name of every seaman or apprentice who ceases to be a member of the crew otherwise than by death, with the place, time, manner, and cause thereof.

10. The wages due to any seaman or apprentice who dies during the voyage, and the gross amount of all deductions to be made therefrom.

11. The sale of the effects of any seaman or apprentice who dies during the voyage, including a statement of each article sold, and the sum received for it.

12. In every case of collision in which it is practicable so to do, the master shall, immediately after the occurrence, cause a statement thereof, and of the circumstances under which the same occurred, to be entered in the official log book.

Every entry hereby required to be made in the official log book shall be signed by the master and by the mate, or some other one of the crew, and every entry in the official log book shall be made as soon as possible after the occurrence to which it relates, and, if not made on the same day as the occurrence to which it relates, shall be made and dated so as to show the date of the occurrence, and of the entry respecting it; and in no case shall any entry therein, in respect of any occurrence happening previously to the arrival of the vessel at her final port, be made more than 24 hours after such arrival.

If in any case the official log book is not kept in the manner hereby required, or if any entry hereby directed to be made in any such log book is not made at the time and in the manner hereby directed, the master shall, for each such offense, be liable to a penalty of not more than $25; and every person who makes, or procures to be made, or assists in making, any entry in any official log book in respect of any occurrence happening previously to the arrival of the vessel at her final port of discharge, more than 24 hours after such arrival, shall, for each offense, be liable to a penalty of not more than $150.

Log Book, Ship's.—(See Draft; Drills; Examination and Test; Fire Duties; Accident Reports.)

Look-Outs and Watchmen.—All vessels navigating the ocean during the nighttime shall have a look-out at all times at or near the bow. Nothing in this rule shall exonerate any master or officer in command from the consequences of any neglect to keep a proper look-out or the neglect of any precaution which may be required by the ordinary practice of seamen or by the special circumstances of the case.

Vessels carrying passengers shall during the nighttime keep a suitable number of watchmen in all passenger quarters and on each deck.

All watchmen shall be under the direct charge of the master or officer in command of the vessel, and each shall report to the officer in command at the pilot house at fixed intervals of not longer than every hour. Cabin watchmen and cabin patrols on duty in the nighttime shall have in their possession while on such patrol duty a suitable and efficient dry-battery flashlight.

The uniform of the night watchman shall be so conspicuous as to be readily distinguished from other persons, and the coat or sweater marked with a rating badge worn on the left sleeve, marked "Watchman," and front of cap marked "Watchman."

On passenger vessels of 15,000 gross tons, and over, the night watchman shall be provided with a punch clock, and a suitable number of keys shall be distributed about the vessel so as to enable the watchman to punch the clock at each station once each hour.

Watchmen or patrolmen shall not be required to perform any other duty while on watch.

Loss of Life.—(See Accident Reports; Official Log Book.)

Lubricating Oil.—(See Inflammable Articles.)

Luminous Life Buoys.—(See Water-lights.)

Manning of Merchant Vessels.—In all merchant vessels of the United States of more than 100 gross tons, excepting those navigating rivers, harbors, bays, or sounds exclusively, the sailors shall, while at sea, be divided into at least two, and the firemen, oilers, and water tenders into at least three watches, which shall be kept on duty successively for the performance of ordinary work incident to the sailing and management of the vessel. The seamen shall not be shipped to work alternately in the fireroom and on deck, nor shall those shipped for deck duty be required to work in the fireroom, or vice versa; but these provisions shall not limit either the authority of the master or other officer or the obedience of the seamen when, in the judgment of the master or other officer, the whole or any part of the crew are needed for the maneuvering of the vessel or the performance of work necessary for the safety of the vessel or her cargo, or for the saving of life aboard other vessels in jeopardy, or when in port or at sea from requiring the whole or any part of the crew to participate in the performance of fire, lifeboat, and other drills. While such vessel is in a safe harbor no seaman shall be required to do any unnecessary work on Sundays or the following named days: New Year's Day, the Fourth of July, Labor Day, Thanksgiving Day, and Christmas Day, but this shall not prevent the dispatch of a vessel on regular schedule or when ready to proceed on her voyage. And at all times while such vessel is in a safe harbor, nine hours, inclusive of the anchor watch, shall constitute a day's work. Whenever the master of any vessel shall fail to comply with this section, the seamen shall be entitled to discharge from such vessel and to receive the wages earned.

No vessel of 100 tons gross and upward, shall be permitted to depart from any port of the United States unless she has on board a crew not less than 75 per cent of which, in each department thereof, are able to understand any order given by the officers of such vessel, nor unless 40 per cent in the first year, 45 per cent in the second year, 50 per cent in the third year, 55 per cent in the fourth year after the passage of this Act, and thereafter 65 per cent of her deck crew, exclusive of licensed officers and apprentices, are of a rating not less than able seaman. Every person shall be rated an able seaman, and qualified for service as

such on the seas, who is 19 years of age or upward, and has had at least three years' service on deck at sea or on the Great Lakes, on a vessel or vessels to which this section applies, including decked fishing vessels, naval vessels, or coast guard vessels; and every person shall be rated an able seaman, and qualified to serve as such on the Great Lakes and on the smaller lakes, bays, or sounds, who is 19 years of age or upward and has had at least 18 months' service on deck at sea or on the Great Lakes or on the smaller lakes, bays, or sounds, on a vessel or vessels to which this section applies, including decked fishing vessels, naval vessels, or coast guard vessels; and graduates of school ships approved by and conducted under rules prescribed by the Secretary of Commerce may be rated able seamen after 12 months' service at sea: Provided, That upon examination, under rules prescribed by the Department of Commerce as to eyesight, hearing, and physical condition, such persons or graduates are found to be competent: Provided further, That upon examination, under rules prescribed by the Department of Commerce as to eyesight, hearing, physical condition, and knowledge of the duties of seamanship a person found competent may be rated as able seaman after having served on deck 12 months at sea, or on the Great Lakes; but seamen examined and rated able seamen under this proviso shall not in any case compose more than one-fourth of the number of able seamen required by this section to be shipped or employed upon any vessel.

Any person may make application to any board of local inspectors for a certificate of service as able seaman, and upon proof being made to said board by affidavit and examination, under rules approved by the Secretary of Commerce, showing the nationality and age of the applicant and the vessel or vessels on which he has had service and that he is entitled to such certificate under the provisions of this section, the board of local inspectors shall issue to said applicant a certificate of service, which shall be retained by him and be accepted as prima facie evidence of his rating as an able seaman.

Each board of local inspectors shall keep a complete record of all certificates of service issued by them and to whom issued and shall keep on file the affidavits upon which said certificates are issued.

The collector of customs may, upon his own motion,

and shall, upon the sworn information of any reputable citizen of the United States setting forth that this section is not being complied with, cause a muster of the crew of any vessel to be made to determine the fact; and no clearance shall be given to any vessel failing to comply with the provisions of this section: Provided, That the collector of customs shall not be required to cause such muster of the crew to be made unless said sworn information has been filed with him for at least six hours before the vessel departs, or is scheduled to depart: Provided further, That any person that shall knowingly make a false affidavit for such purpose shall be deemed guilty of perjury and upon conviction thereof shall be punished by a fine not exceeding $500 or by imprisonment not exceeding one year, or by both such fine and imprisonment, within the discretion of the court. Any violation of any provision of this section by the owner, master, or officer in charge of the vessel shall subject the owner of such vessel to a penalty of not less than $100 and not more than $500.

Marking of Equipment.—(See Equipment.)

Masks.—(See Gas Masks.)

Matches.—Friction matches may be carried when securely packed in strong, tight chests or boxes, the covers of which shall be well secured by locks, screws, or other reliable fastenings, and stowed in a safe part of the vessel at a secure distance from any fire or heat. The package shall be distinctly marked on the outside, with the name or description of the article contained therein.

Means of Escape.—(See Exits.)

Measurement.—Before any vessel shall be registered, she shall be measured by a surveyor, if there be one, or by the person he shall appoint, at the port or place where the vessel may be, and if there be none, by such person as the collector of the district within which she may be shall appoint. But in all cases where a vessel has before been registered as a vessel of the United States, it shall not be necessary to measure her anew, for the purpose of obtaining another register; unless such vessel has undergone some alteration as to her burden, subsequent to the time of her former registry.

The officer or person by whom such measurement is made shall, for the information of and as a voucher to the officer by whom the registry is to be made, grant a certificate, specifying the build of the vessel, her number of decks

and masts, her length, breadth, depth, the number of tons she measures, and such other particulars as are usually descriptive of the identity of a vessel, and that her name, and the place to which she belongs are painted on her stern in proper manner; which certificate shall be countersigned by an owner, or by the master of such vessel, or by some other person who shall attend her admeasurement, on behalf of her owner or owners, in testimony of the truth of the particulars therein contained; without which the certificate shall not be valid.

Medicines and Antiscorbutics.—Every vessel belonging to a citizen of the United States, bound from a port in the United States to any foreign port, or being of the burden of 75 tons or upward, and bound from a port on the Atlantic to a port on the Pacific, or vice versa, shall be provided with a chest of medicines; and every sailing vessel bound on a voyage across the Atlantic or Pacific Ocean, or around Cape Horn, or the Cape of Good Hope, or engaged in the whale or other fisheries, or in sealing, shall also be provided with, and cause to be kept, a sufficient quantity of lime or lemon juice, and also sugar and vinegar, or other antiscorbutics, to be served out to every seaman as follows: The master of every such vessel shall serve the lime or lemon juice, and sugar and vinegar, to the crew, within ten days after salt provisions mainly have been served out to the crew, and so long afterward as such consumption of salt provisions continues; the lime or lemon juice and sugar daily at the rate of half an ounce each per day; and the vinegar weekly at the rate of half a pint per week for each member of the crew.

If, on any such vessel, such medicines, medical stores, lime or lemon juice, or other articles, sugar, and vinegar, as are required by the preceding section, are not provided and kept on board, as required, the master or owner shall be liable to a penalty of not more than $500; and if the master of any such vessel neglects to serve out the lime or lemon juice, and sugar and vinegar in the case and manner directed, he shall for each such offense be liable to a penalty of not more than $100; and if any master is convicted in either of the offenses mentioned in this section, and it appears that the offense is owing to the act or default of the owner, such master may recover the amount of such penalty, and the costs incurred by him, from the owner.

Monthly Reports.—(See Emergency Signals.)

Muster Lists.—(See Station Bills.)

Name of Vessel.—The name of every documented vessel of the United States shall be marked upon each bow and upon the stern, and the home port shall also be marked upon the stern. These names shall be painted or gilded, or consist of cut or carved or cast roman letters in light color on a dark ground, or in a dark color on a light ground, secured in place, and to be distinctly visible. The smallest letters used shall not be less in size than 4 inches. If any such vessel shall be found without these names being so marked the owner or owners shall be liable to a penalty of $10 for each name omitted.

Name on Equipment.—(See Equipment.)

Name on Steamer.—Every steam vessel of the United States, in addition to having her name painted on her stern, shall have the same conspicuously placed in distinct, plain letters, of not less than six inches in length, on each outer side of the pilot-house, if it has such, and in case the vessel has side-wheels, also on the outer side of each wheel-house; and if any such steamboat be found without having her name placed as required, she shall be subject to the same penalty and forfeiture as provided by law in the case of a vessel of the United States found without having her name, and the name of the port to which she belongs, painted on her stern.

Naphtha.—(See Cargo and Stores prohibited on passenger steamers.)

Net Tonnage.—(See Tonnage.)

New Vessels.—On and after July 1, 1911, the owner of every new vessel of over 100 gross tons, when making application for first inspection of the vessel, shall furnish the local inspectors of the district where the vessel is to be inspected drawings or blue prints, in plan and section, showing fully the general construction of the vessel, of wood, iron, or steel, including dimensions, spacing of frames, disposition of hull plates, outside and in, or of outside and inside planks, construction of decks, construction of transverse and longitudinal bulkheads and location of same, space between decks, and details or principal scarfs, and shall also furnish a statement of the shapes, dimensions, and unit weights of all constructural parts of the hull and of the kinds of material of which made, including kinds of wood. A full description of the riveting of all parts of an iron or steel hull shall be furnished.

The drawings or blue prints and description of the vessel shall be retained in the office of the local inspectors making the first inspection of vessel.

Nitroglycerin.—(See Cargo and Stores prohibited on passenger steamers.)

Notices to be Posted on Steamers Carrying Passengers.—Certificate of Inspection; 2 copies of Safety First; 3 copies Excluding Certain Persons from Pilot House; 3 copies of Station Bills Required; 5 copies of Line Carrying Gun Drill; Station Bills for Fire and Boat Drills for Deck, Engineer and Steward's department; Life Preserver notices to be posted in each stateroom and in conspicuous places around vessel; 2 Pilot rules framed under glass. Also to have on board 2 copies of law governing the Steamboat Inspection Service and 1 copy of General Rules and Regulations of the Board of Supervising Inspectors. (See Gunpowder.)

Nozzles.—(See Fire Pumps and Hose.)

Number.—(See Official Number.)

Obstructing Channels.—It shall not be lawful to tie up or anchor vessels or other craft in navigable channels in such a manner as to prevent or obstruct the passage of other vessels or craft; or to voluntarily or carelessly sink, or permit or cause to be sunk, vessels or other craft in navigable channels; or to float loose timber and logs, or to float what is known as sack rafts of timber and logs in streams or channels actually navigated by steamboats in such manner as to obstruct, impede, or endanger navigation. And whenever a vessel, raft, or other craft is wrecked and sunk in a navigable channel, accidentally or otherwise, it shall be the duty of the owner of such sunken craft to immediately mark it with a buoy or beacon during the day and a lighted lantern at night, and to maintain such marks until the sunken craft is removed or abandoned, and the neglect or failure of the said owner so to do shall be unlawful; and it shall be the duty of the owner of such sunken craft to commence the immediate removal of the same, and prosecute such removal diligently, and failure to do so shall be considered as an abandonment of such craft, and subject the same to removal by the United States.

Offenses and Punishments.—Whenever any seaman who has been lawfully engaged or any apprentice to the sea service commits any of the following offenses, he shall be punished as follows:

1. For desertion, by forfeiture of all or any part of the clothes or effects he leaves on board and of all or any part of the wages or emoluments which he has then earned.

2. For neglecting or refusing without reasonable cause to join his vessel or to proceed to sea in his vessel, or for absence without leave at any time within 24 hours of the vessel's sailing from any port, either at the commencement or during the progress of the voyage, or for absence at any time without leave and without sufficient reason from his vessel and from his duty, not amounting to desertion, by forfeiture from his wages of not more than two days' pay or sufficient to defray any expenses which shall have been properly incurred in hiring a substitute.

3. For quitting the vessel without leave, after her arrival at the port of her delivery and before she is placed in security, by forfeiture from his wages of not more than one month's pay.

4. For willful disobedience to any lawful command at sea, by being, at the option of the master, placed in irons until such disobedience shall cease, and upon arrival in port by forfeiture from his wages of not more than four days' pay, or, at the discretion of the court, by imprisonment for not more than one month.

5. For continued willful disobedience to lawful command or continued willful neglect of duty at sea, by being, at the option of the master, placed in irons, on bread and water, with full rations every fifth day, until such disobedience shall cease, and upon arrival in port by forfeiture, for every 24 hours' continuance of such disobedience or neglect, of a sum of not more than 12 days' pay, or by imprisonment for not more than 3 months, at the discretion of the court.

6. For assaulting any master or mate, by imprisonment for not more than two years.

7. For willfully damaging the vessel, or embezzling or willfully damaging any of the stores or cargo, by forfeiture out of his wages of a sum equal in amount to the loss thereby sustained, and also, at the discretion of the court, by imprisonment for not more than 12 months.

8. For any act of smuggling for which he is convicted and whereby loss or damage is occasioned to the master or owner, he shall be liable to pay such master or owner such a sum as is sufficient to reimburse the master or owner for such loss or damage, and the whole or any part of his wages

may be retained in satisfaction or on account of such liability, and he shall be liable to imprisonment for a period of not more than 12 months.

Upon the commission of any of the offenses enumerated in the preceding section any entry thereof shall be made in the official log book on the day on which the offense was committed, and shall be signed by the master and by the mate or one of the crew; and the offender, if still in the vessel, shall, before her next arrival at any port, or, if she is at the time in port, before her departure therefrom, be furnished with a copy of such entry and have the same read over distinctly and audibly to him, and may thereupon make such a reply thereto as he thinks fit; and a statement that a copy of the entry has been so furnished, or the same has been so read over, together with his reply, if any, made by the offender, shall likewise be entered and signed in the same manner. In any subsequent legal proceedings the entries hereinbefore required shall, if practicable, be produced or proved, and in default of such production of proof the court hearing the case may, at its discretion, refuse to receive evidence of the offense.

All clothes, effects, and wages which, under the provisions of this Title, are forfeited for desertion, shall be applied, in the first instance, in payment of the expenses occasioned by such desertion, to the master or owner of the vessel from which the desertion has taken place, and the balance, if any, shall be paid by the master or owner to any shipping commissioner resident at the port at which the voyage of such vessel terminates; and the shipping commissioner shall account for and pay over such balance to the judge of the district court within one month after the commissioner receives the same, to be disposed of by him in the same manner as is prescribed for the disposal of the money, effects, and wages of deceased seamen. Whenever any master or owner neglects or refuses to pay over to the shipping commissioner such balance, he shall be liable to a penalty of double the amount thereof, recoverable by the commissioner in the same manner that seamen's wages are recovered. In all other cases of forfeiture of wages the forfeiture shall be for the benefit of the master or owner by whom the wages are payable.

Any master of, or any seaman or apprentice belonging to, any merchant vessel, who, by willful breach of duty, or by reason of drunkenness, does any act tending to the

immediate loss or destruction of, or serious damage to such vessel, or tending immediately to endanger the life or limb of any person belonging to or on board of such vessel; or who, by willful breach of duty, or by neglect of duty, or by reason of drunkenness, refuses or omits to do any lawful act proper and requisite to be done by him for preserving such vessel from immediate loss, destruction, or serious damage, or for preserving any person belonging to or on board of such ship from immediate danger to life or limb, shall, for every such offense, be deemed guilty of a misdemeanor, punishable by imprisonment for not more than 12 months.

No seaman in the merchant service shall wear any sheath knife on shipboard. It shall be the duty of the master of any vessel registered, enrolled, or licensed under the laws of the United States, and of the person entering into contract for the employment of a seaman upon any such vessel, to inform every person offering to ship himself of the provisions of this section, and to require his compliance therewith, under a penalty of $50 for each omission, to be sued for and recovered in the name of the United States, under the direction of the Secretary of Commerce; one-half for the benefit of the informer, and the other half for the benefit of the fund for the relief of sick and disabled seamen.

Official Log Book.—(See Log Book.)

Official Number.—The Commissioner of Navigation shall have power, under such regulations as he shall prescribe, to establish and provide a system of numbering vessels so registered, enrolled, and licensed; and each vessel so numbered shall have her number deeply carved or otherwise permanently marked on her main beam; and if at any time she shall cease to be so marked, such vessel shall be liable to a fine of $30 on every arrival in a port of the United States if she have not her proper official number legally carved or permanently marked.

Oil Allowed as Stores.—(See Inflammable Articles.)

Oil as Fuel.—(See Application to Use Petroleum as Fuel.)

Oil for Auxiliaries.—(See Gasoline as Fuel for Auxiliary Plants.)

Oil for Storms.—(See Storm Oil.)

Oil Lamps.—(See Auxiliary Lighting System.)

Oils Not Allowed.—(See Inflammable Articles.)

Oil Pollution Act.—(When used in this Act, unless the context otherwise requires):

(*a*) The term "oil" means oil of any kind or in any form, including fuel oil, oil sludge, and oil refuse;

(*b*) The term "person" means an individual, partnership, corporation, or association; any owner, master, officer, or employee of a vessel; and any officer, agent, or employee of the United States;

(*c*) The term "coastal navigable waters of the United States" means all portions of the sea within the territorial jurisdiction of the United States, and all inland waters navigable in fact in which the tide ebbs and flows;

(*d*) The term "Secretary" means the Secretary of War.

Except in case of emergency imperilling life or property, or unavoidable accident, collision, or stranding, and except as otherwise permitted by regulations prescribed by the Secretary, it shall be unlawful for any person to discharge, or suffer, or permit the discharge of oil by any method, means, or manner into or upon the coastal navigable waters of the United States from any vessel using oil as fuel for the generation of propulsion power, or any vessel carrying or having oil thereon in excess of that necessary for its lubricating requirements and such as may be required under the laws of the United States and the rules and regulations prescribed thereunder. The Secretary is authorized and empowered to prescribe regulations permitting the discharge of oil from vessels in such quantities, under such conditions, and at such times and places as, in his opinion, will not be deleterious to health or sea food, or a menace to navigation, or dangerous to persons or property engaged in commerce on such waters, and for the loading, handling, and unloading of oil (Sec. 3).

Any person who violates Section 3 of this Act, or any regulation prescribed in pursuance thereof, is guilty of a misdemeanor, and upon conviction shall be punished by a fine not exceeding $2,500 nor less than $500, or by imprisonment not exceeding one year nor less than 30 days, or by both such fine and imprisonment, for each offense. And any vessel (other than a vessel owned and operated by the United States) from which oil is discharged in violation of Section 3 of this Act, or any regulation prescribed in pursuance thereof, shall be liable for the pecuniary penalty specified in this section, and clearance of such vessel from a port of the United States may be withheld until the

penalty is paid, and said penalty shall constitute a lien on such vessel which may be recovered in proceedings by libel in rem in the district court of the United States for any district within which the vessel may be.

A board of local inspectors of vessels may suspend or revoke a license issued by any such board to the master or other licensed officer of any vessel found violating the provisions of Section 3 of this Act.

Oil Rooms.—(See Lamp Lockers.)

Only Certain Persons Allowed in Pilot House and on Navigator's Bridge.—Masters and pilots of vessels carrying passengers shall exclude from the pilot house and navigator's bridge of such vessels, while under way, all persons not connected with the navigation of such vessels: Provided, That officers of the Bureau of Navigation and Steamboat Inspection, licensed officers of vessels, persons regularly engaged in learning the profession of pilot, officers of the United States Coast Guard, United States Navy, United States Coast and Geodetic Survey, United States Lighthouse Service, and the Engineer Department of the United States Army, may be allowed in the pilot house or upon the navigator's bridge upon the responsibility of the officer in charge.

The master of every such passenger and ferry vessel shall keep three printed copies of this section posted in conspicuous places on such vessel, one of which shall be kept posted in the pilot house.

Papers Relating to Crew.—The following rules shall be observed with reference to vessels bound on any foreign voyage:

1. The duplicate list of the ship's company, required to be made out by the master and delivered to the collector of the customs, shall be a fair copy in one uniform handwriting, without erasure or interlineation.

2. It shall be the duty of the owners of every such vessel to obtain from the collector of the customs of the district from which the clearance is made, a true and certified copy of the shipping articles, containing the names of the crew, which shall be written in a uniform hand, without erasures or interlineations.

3. These documents, which shall be deemed to contain all the conditions of contract with the crew as to their service, pay, voyage, and all other things, shall be produced by the master, and laid before any consul of the United

States, whenever he may deem their contents necessary to enable him to discharge the duties imposed upon him by law toward any mariner applying to him for his aid or assistance.

4. All interlineations, erasures, or writing in hand different from that in which such duplicates were originally made, shall be deemed fraudulent alterations, working no change in such papers, unless satisfactorily explained in a manner consistent with innocent purposes and the provisions of law which guard the rights of mariners.

5. If any master of a vessel shall proceed on a foreign voyage without the documents herein required, or refuse to produce them when required, or to perform the duties imposed by this section, or shall violate the provisions thereof, he shall be liable to each and every individual injured thereby in damages, to be recovered in any court of the United States in the district where such delinquent may reside or be found, and in addition thereto be punishable by a fine of $100 for each offense.

6. It shall be the duty of the boarding officer to report all violations of this section to the collector of the port where any vessel may arrive, and the collector shall report the same to the Secretary of Commerce and to the United States attorney in his district.

Passenger Accommodation Inspection.—The collector of customs of the collection district within which, or the surveyor of the port at which, any such steamship or other vessel arrives, shall direct an inspector or other officer of the customs to make an examination of the vessel, and to admeasure the compartments or spaces occupied by the emigrant passengers, or passengers other than cabin passengers, during the voyage; and such measurement shall be made in the manner provided by law for admeasuring vessels for tonnage; and to compare the number of such passengers found on board with the list of such passengers furnished by the master to the customs officer; and the said inspector or other officer shall make a report to the aforesaid collector or surveyor, stating the port of departure, the time of sailing, the length of the voyage, the ventilation, the number of such passengers on board the vessel, and their native country, respectively; the cubic quantity of each compartment or space; and the number of berths and passengers in each space, the kind and quality of the food furnished to such passengers on the voyage; the num-

ber of deaths, and the age and sex of those who died during the voyage, and of what disease; and in case there was any unusual sickness or mortality during the voyage to, report whether the same was caused by any neglect or violation of the provisions of this Act, or by the want of proper care against disease by the master or owners of the vessel; and the said reports shall be forwarded to the Secretary of Commerce at such times and in such manner as he shall direct.

Passengers Allowed.—It shall not be lawful to take on board of any vessel a greater number of passengers than is stated in the certificate of inspection, and for every violation of this provision the master or owner shall be liable to any person suing for the same to forfeit the amount of passage money and $10 for each passenger beyond the number allowed.

The master or owner of the vessel, or either or any of them, who shall knowingly violate this provision shall be liable to a fine of not more than $100 or imprisonment of not more than thirty days, or both.

Passengers Carried.—The master of every passenger steamer shall keep a correct count of all the passengers received and delivered from day to day, which count shall be open to the inspection of the inspectors and officers of the customs at all times, and the aggregate number of passengers shall be furnished to inspectors as often as called for: Provided, however, That a correct list of passengers received and delivered from day to day shall be kept, instead of a correct count, by the masters of seagoing passenger steamers in the coastwise trade and by the masters of passenger steamers on the Great Lakes on routes exceeding 300 miles: Provided further, That nothing herein shall affect existing laws relative to vessels running between this country and foreign ports.

Every master of any passenger steamer who fails through negligence or design, to keep a count or list of passengers as required shall be liable to a penalty of $100.

Passenger List.—On the arrival of any steamship or other vessel within any collection district of the United States, the master shall submit for inspection to the officer of customs who first makes demand therefor, and shall subsequently deliver with his manifest of cargo on entry, a correct list, signed and verified on oath by the master, of all passengers taken on board the vessel at any foreign

port or place, specifying, in the manner to be prescribed from time to time by the Secretary of Commerce, the name of each passenger, age (if a child of eight years or under), sex, married or single, location of compartment or space occupied during the voyage (if the passenger be other than a cabin passenger), whether a citizen of the United States, number of pieces of baggage, and if any passenger die on the voyage the list shall specify the name, age, and cause of death of each deceased passenger. For a violation of this provision, or for permitting or neglecting to prevent a violation thereof, the master of the vessel shall be liable to a fine not exceeding $1,000.

Penalties.—(See Accident Reports; Cable for Communication; Charter Party; Collision; Condition of Vessel and Equipment; Drills; Hatches; Licensed Officers; Monthly Reports; Name on Steamer; Passengers Allowed; Passengers Carried; Searchlight; Sanitary Condition; Slop Chest; Unnecessary Lights; Unnecessary Whistles.)

Penalty for Shipment without Agreement.—If any person shall be carried to sea, as one of the crew on board of any vessel making a voyage, without entering into an agreement with the master of such vessel, in the form and manner, and at the place and times in such cases required, the vessel shall be held liable for each such offense to a penalty of not more than $200. But the vessel shall not be held liable for any person carried to sea, who shall have secretly stowed away himself without the knowledge of the master, mate, or of any of the officers of the vessel, or who shall have falsely personated himself to the master, mate, or officers of the vessel, for the purpose of being carried to sea.

If any master, mate, or other officer of a vessel knowingly receives, or accepts, to be entered on board of any merchant vessel any seaman who has been engaged or supplied contrary to the provisions of this Title, the vessel on board of which such seaman shall be found shall, for every such seaman, be liable to a penalty of not more than $200.

Period of Engagement.—A master of a vessel in the foreign trade may engage a seaman at any port in the United States, in the manner provided by law, to serve on a voyage to any port, or for the round trip from and to the port of departure, or for a definite time, whatever the destination. The master of a vessel making regular and stated trips between the United States and a foreign country may engage a seaman for one or more round trips, or

for a definite time, or on the return of said vessel to the United States may reship such seaman for another voyage in the same vessel, in the manner provided by law, without the payment of additional fees to any officer for such reshipment or reengagement.

Petroleum.—(See Cargo and Stores Prohibited on Passenger Steamers; Gasoline; Inflammable Articles.)

Physical Examination.—Medical Examinations for Original License, Renewals and Raise of Grade: No original license shall be issued except upon the official certificate of a surgeon of the Public Health Service respecting the eyesight, hearing, and physical condition of the applicant. The word "original," as contemplated in this section, shall mean the first license of any character, except operator's license, issued to the applicant.

In the event an inspector finds that an applicant for raise of grade or renewal of license obviously suffers from nearsightedness, eye disease, poor hearing, or some other physical or mental infirmity to a degree that, in the opinion of the inspector, would render him incompetent to perform the ordinary duties of an officer at sea, he shall be required to undergo an examination by a surgeon of the Public Health Service to determine his competency in such respects.

If the applicant subsequently produces a certificate from the Public Health Service to the effect that his condition has improved to a satisfactory degree, or is normal, he shall be qualified in this respect.

Where from distance, or other cause, the applicant would be put to great inconvenience or expense to appear before a surgeon of the Public Health Service for examination, the certificate of a reputable physician, or an oculist for vision or color sense, may be accepted in lieu of the certificate of the Surgeon General of the Public Health Service: Provided, That the Supervising Inspector General may waive the examination for original license for a like cause, except the examination for acuity of vision and color sense.

Applicants for original and renewal of license as deck officer shall be examined as to ability to distinguish colors.

In case an applicant for original or renewal of license is pronounced color blind, he may, in the discretion of the inspectors, be limited to act as master, mate, or pilot on a vessel navigating in daylight only.

Nothing herein contained shall debar an applicant who has lost the sight of one eye from securing a renewal of his license, providing that his color sense is normal.

In every case arising under this section applicants shall have the right of appeal to the supervising inspector of the district and to the Supervising Inspector General, whose decision shall be final.

Pilot Laws.—Until further provision is made by Congress, all pilots in the bays, inlets, rivers, harbors, and ports of the United States shall continue to be regulated in conformity with the existing laws of the States respectively wherein such pilots may be, or with such laws as the States may respectively enact for the purpose.

The master of any vessel coming into or going out of any port situate upon waters which are the boundary between two States, may employ any pilot duly licensed or authorized by the laws of either of the States bounded on such waters, to pilot the vessel to or from such port.

No regulations or provisions shall be adopted by any State which shall make any discrimination in the rate of pilotage or half pilotage between vessels sailing between the ports of one State and vessels sailing between the ports of different States, or any discrimination against vessels propelled in whole or in part by steam, or against national vessels of the United States; and all existing regulations or provisions making any such discrimination are annulled and abrogated.

No State or municipal government shall impose upon pilots of steam vessels any obligation to procure a State or other license in addition to that issued by the United States, or any other regulation which will impede such pilots in the performance of the duties required by this Title; nor shall any pilot charges be levied by any such authority upon any steamer piloted as provided by this Title; and in no case shall the fees charged for the pilotage of any steam vessel exceed the customary or legally established rates in the State where the same is performed. Nothing in this Title shall be construed to annul or affect any regulation established by the laws of any State, requiring vessels entering or leaving a port in any such State, other than coastwise steam vessels, to take a pilot duly licensed or authorized by the laws of such State, or of a State situate upon the waters of such State.

All coastwise seagoing vessels, and vessels navigating

the Great Lakes, shall be subject to the navigation laws of the United States, when navigating within the jurisdiction thereof; and all vessels, propelled in whole or in part by steam, and navigating as aforesaid, shall be subject to all the rules and regulations established in pursuance of law for the government of steam vessels in passing, as provided by this Title; and every coastwise seagoing steam vessel subject to the navigation laws of the United States, and to the rules and regulations aforesaid, not sailing under register, shall, when under way, except on the high seas, be under the control and direction of pilots licensed by the inspectors of steamboats.

Place of Registry.—Every vessel, except as is hereinafter provided, shall be registered by the collector of that collection district which includes the port to which such vessel shall belong at the time of her registry; which port shall be deemed to be that at or nearest to which the owner, if there be but one, or, if more than one, the husband or acting and managing owner of such vessel, usually resides.

Port Defined.—The word "port" shall be construed to mean either the port where the vessel is registered or enrolled, or the place in the same district where the vessel was built or where one or more of the owners reside.

Every steam vessel of the United States, in addition to having her name painted on her stern, shall have the same conspicuously placed in distinct, plain letters, of not less than six inches in length on each outer side of the pilot house, if it has such, and in case the vessel has side wheels, also on the outer side of each wheelhouse; and if any such steamboat be found without having her name placed as required, she shall be subject to the same penalty and forfeiture as provided by law in the case of a vessel of the United States found without having her name, and the name of the port to which she belongs, painted on her stern.

Portholes.—(See Deadlights and Air Ports.)

Provisions and Water.—Should any master or owner of any merchant vessel of the United States neglect to provide a sufficient quantity of stores to last for a voyage of ordinary duration to the port of destination, and in consequence of such neglect the crew are compelled to accept a reduced scale, such master or owner shall be liable to a penalty as provided below.

Any three or more of the crew of any merchant vessel of the United States bound from a port in the United States

to any foreign port, or being of the burden of 75 tons or upward, and bound from a port on the Atlantic to a port on the Pacific, or vice versa, may complain to any officer in command of any of the vessels of the United States Navy, or consular officer of the United States, or shipping commissioner or chief officer of the customs, that the provisions or water for the use of the crew are, at any time, of bad quality, unfit for use, or deficient in quantity. Such officer shall thereupon examine the provisions or water, or cause them to be examined; and if, on examination, such provisions or water are found to be of bad quality and unfit for use, or to be deficient in quantity, the person making such examination shall certify the same in writing to the master of the ship. If such master does not thereupon provide other proper provisions or water, where the same can be had, in lieu of any so certified to be of bad quality and unfit for use, or does not procure the requisite quantity of any so certified to be insufficient in quantity, or uses any provisions or water which have been so certified as aforesaid to be of bad quality and unfit for use, he shall, in every such case, be liable to a penalty of not more than $100; and upon every such examination the officers making or directing the same shall enter a statement of the result of the examination in the log book, and shall send a report thereof to the district judge for the judicial district embracing the port to which such vessel is bound; and such report shall be received in evidence in any legal proceedings.

If the officer to whom any such complaint in regard to the provisions or the water is made certifies in such statement that there was no reasonable ground for such complaint, each of the parties so complaining shall forfeit to the master or owner his share of the expense, if any, of the survey.

If any seamen, while on board any vessel, shall state to the master that they desire to make complaint, in accordance with the two preceding sections, in regard to the provisions or the water, to a competent officer, against the master, the master shall, if the vessel is then at a place where there is any such officer, so soon as the service of the vessel will permit, and if the vessel is not then at such a place, so soon after her first arrival at such place as the service of the vessel will permit, allow such seamen, or any of them, to go ashore, or shall send them ashore, in proper custody, so that they may be enabled to make such complaint; and

shall, in default, be liable to a penalty of not more than $100.

If, during a voyage, the allowance of any of the provisions which any seaman is entitled to is reduced except for any time during which such seaman willfully and without sufficient cause refuses or neglects to perform his duty, or is lawfully under confinement for misconduct either on board or on shore; or if it shall be shown that any of such provisions are, or have been during the voyage, bad in quality or unfit for use, the seaman shall receive, by way of compensation for such reduction or bad quality, according to the time of its continuance, the following sums, to be paid him in addition to and to be recoverable as wages:

First: If his allowance is reduced by any quantity not exceeding one-third of the quantity specified by law, a sum not exceeding fifty cents a day.

Second: If his allowance is reduced by more than one-third of such quantity, a sum not exceeding one dollar a day.

Third: In respect to bad quality, a sum not exceeding one dollar a day.

But if it is shown to the satisfaction of the court before which the case is tried that any provisions, the allowance of which has been reduced, could not be procured or supplied in sufficient quantities, or were unavoidably injured or lost, or if by reason of its innate qualities any article becomes unfit for use and that proper and equivalent substitutes were supplied in lieu thereof, the court shall take such circumstances into consideration and shall modify or refuse compensation, as the justice of the case may require.

Pumps.—(See Fire Hose and Pumps.)

Quarantine Inspection.—On the arrival of an infected vessel at any port not provided with proper facilities for treatment of the same, the Secretary of the Treasury may remand said vessel, at its own expense, to the nearest national or other quarantine station, where accommodations and appliances are provided for the necessary disinfection and treatment of the vessel, passengers, and cargo; and after treatment of any infected vessel at a national quarantine station, and after certificate shall have been given by the United States quarantine officer at said station that the vessel, cargo, and passengers are each and all free from infectious disease, or danger of conveying the same, said vessel shall be admitted to entry at any port of

the United States named within the certificate. But any ports where sufficient quarantine provisions have been made by State or local authorities the Secretary of the Treasury may direct vessels bound for said ports to undergo quarantine at said State or local station.

Quarters and Facilities for Crew.—Every place appropriated to the crew of the vessel shall have a space of not less than 72 cubic feet and not less than 12 superficial feet, measured on the deck or floor of that place, for each seaman or apprentice lodged therein. The provisions of this Act requiring a crew space of 72 cubic feet per man shall apply only to vessels the construction of which shall be begun after June 30, 1895. Such place shall be securely constructed, properly lighted, drained, and ventilated, properly protected from weather and sea, and as far as practicable properly shut off and protected from the effluvium of cargo or bilge water; and failure to comply with this provision shall subject the owner to a penalty of $500. Every place so occupied shall be kept free from goods or stores of any kind not being the personal property of the crew in use during the voyage; and if any such place is not so kept free the master shall forfeit and pay to each seaman the sum of fifty cents a day for each day during which any goods or stores as aforesaid are kept or stored in the place after complaint has been made to him by any two or more of the seamen so lodged. No deduction from tonnage shall be made unless there is permanently cut in a beam and over the doorway of every such place the number of men it is allowed to accommodate with these words, "certified to accommodate —— seamen." (Aug. 5, 1882; Mar. 2, 1895.)

On all merchant vessels of the United States the construction of which shall be begun after the passage of this Act, except yachts, pilot boats, or vessels of less than 100 tons register, every place appropriated to the crew of the vessel shall have a space of not less than 120 cubic feet and not less than 16 square feet, measured on the floor or deck of that place, for each seaman or apprentice lodged therein, and each seaman shall have a separate berth and not more than one berth shall be placed one above another; such place or lodging shall be securely constructed, properly lighted, drained, heated, and ventilated, properly protected from weather and sea, and, as far as practicable, properly shut off and protected from the effluvium of cargo or bilge

water. And every such crew space shall be kept free from goods or stores not being the personal property of the crew occupying said place in use during the voyage. (Mar. 3, 1897.)

That in addition to the space allotment for lodgings hereinbefore provided, on all merchant vessels of the United States which in the ordinary course of their trade make voyages of more than three days' duration between ports, and which carry a crew of twelve or more seamen, there shall be constructed a compartment, suitably separated from other spaces, for hospital purposes, and such compartment shall have at least one bunk for every twelve seamen, constituting her crew, provided that not more than six bunks shall be required in any case.

All merchant vessels of the United States, the construction of which shall be begun after the passage of this Act, having more than ten men on deck must have at least one light, clean, and properly ventilated washing place. There shall be provided at least one washing outfit for every two men of the watch. The washing place shall be properly heated. A separate washing place shall be provided for the fireroom and engine room men, if their number exceed ten, which shall be large enough to accommodate at least one-sixth of them at the same time, and have hot and cold water supply and a sufficient number of wash basins, sinks, and shower baths.

Any failure to comply with this section shall subject the owner or owners of such vessel to a penalty of not less than $50 nor more than $500: Provided, That forecastles shall be fumigated at such intervals as may be provided by regulations to be issued by the Surgeon General of the Public Health Service, with the approval of the Department of Commerce, and shall have at least two exits, one of which may be used in emergencies. (Mar. 4, 1915.)

Radio Lead-Ins.—(See Dangerous Places.)

Recharges.—(See Fire Extinguishers.)

Registered Vessels.—Vessels built within the United States and belonging wholly to citizens thereof; and vessels which may be captured in war by citizens of the United States and lawfully condemned as prize, or which may be adjudged to be forfeited for a breach of the laws of the United States; and seagoing vessels, whether steam or sail, which have been certified by the Steamboat Inspection Service as safe to carry dry and perishable cargo, wherever

built, which are to engage only in trade with foreign countries or with the Philippine Islands and the islands of Guam and Tutuila, being wholly owned by citizens of the United States or corporations organized and chartered under the laws of the United States or of any State thereof, the president and managing directors of which shall be citizens of the United States, and no others, may be registered as directed in this Title. Foreign-built vessels registered pursuant to this Act shall not engage in the coastwise trade.

Register Tonnage.—(See Tonnage.)

Relieving Tackles.—(See Extra Steering Apparatus.)

Removal of Master.—Any person or body corporate having more than one-half ownership of any vessel shall have the same power to remove a master, who is also part owner of such vessel, as such majority owners have to remove a master not an owner. This section shall not apply where there is a valid written agreement subsisting by virtue of which such master would be entitled to possession.

Repaired Wrecks.—The Secretary of Commerce may issue a register or enrollment for any vessel wrecked on the coasts of the United States or her possessions or adjacent waters, when purchased by a citizen or citizens of the United States and thereupon repaired in a shipyard in the United States or her possessions, if it shall be proved to the satisfaction of the Secretary of Commerce, if he deems it necessary, through a board of three appraisers appointed by him, that the said repairs put upon such vessels are equal to three times the appraised salved value of the vessel: Provided, That the expense of the appraisal herein provided for shall be borne by the owner of the vessel: Provided further, That if any of the material matters of fact sworn to or represented by the owner, or at his instance, to obtain the register of any vessel are not true, there shall be a forfeiture to the United States of the vessel in respect to which the oath shall have been made, together with tackle, apparel, and furniture thereof.

Repairs and Alterations.—No repairs or alterations affecting the safety of the vessel, either in regard to hull or machinery, shall be made without the knowledge of the local inspectors. Notice of such repairs and changes is necessary, even if such work does not require the vessel to be placed in a dry dock, and even if there are no licensed officers attached to the vessel.

Repeating Tube.—(See Bell Signals.)

Reports to Local Inspectors.—(See Condition of Vessel; Drills; Dry Dock; Fire Duties; Accident Reports; Collisions; Monthly Reports; Repairs and Alterations; Licensed Officers; Emergency Signals.)

Return of Seamen from Foreign Ports, Alaska, and Insular Ports.—It shall be the duty of the consuls and viceconsuls, from time to time, to provide for the seamen of the United States, who may be found destitute within their districts, respectfully, sufficient subsistence and passages to some port in the United States, in the most reasonable manner, at the expense of the United States, subject to such instructions as the Secretary of State shall give. The seamen shall, if able, be bound to do duty on board the vessels in which they may be transported, according to their several abilities.

Relief and protection of American seamen in foreign countries, in the Panama Canal Zone, and in the Philippine Islands, and shipwrecked American seamen in the Territory of Alaska, in the Hawaiian Islands, Porto Rico, the Virgin Islands, $125,000: Provided, That hereafter the amount agreed upon between the consular officer and the master of the vessel in each individual case not in excess of the lowest passenger rate of such vessel and not in excess of 2 cents per mile, together with such additional compensation for transporting sick or disabled seamen as is now provided by law, shall in each case constitute the lawful rate for transportation on steam vessels.

All masters of vessels of the United States, and bound to some port of the same, are required to take such destitute seamen on board their vessels, at the request of consular officers, and to transport them to the port in the United States to which such vessel may be bound, on such terms, not exceeding ten dollars for each person for voyage of not more than thirty days, and not exceeding $20 for each person for longer voyage, as may be agreed between the master and the consular officer, when the transportation is by a sailing vessel; and the regular steerage passenger rate not to exceed 2 cents per mile when the transportation is by steamer; and said consular officer shall issue certificates for such transportation, which certificates shall be assignable for collection. If any such destitute seaman is so disabled or ill as to be unable to perform duty, the consular officer shall so certify in the certificate of trans-

portation, and such additional compensation shall be paid as the Comptroller General shall deem proper. Every such master who refuses to receive and transport such seamen on the request or order of such consular officer shall be liable to the United States in a penalty of $100 for each seaman so refused. The certificate of any such consular officer, given under his hand and official seal, shall be presumptive evidence of such refusal in any court of law having jurisdiction for the recovery of the penalty. No master of any vessel shall, however, be obliged to take a greater number than one man to every 100 tons burden of the vessel on any one voyage, or to take any seaman having a contagious disease.

Whenever distressed seamen of the United States are transported from foreign ports where there is no consular officer of the United States, to ports of the United States, there shall be allowed to the master or owner of each vessel, in which they are transported, such reasonable compensation, in addition to the allowance now fixed by law, as shall be deemed equitable by the Comptroller General.

Salvage at Sea.—The right to remuneration for assistance or salvage services shall not be affected by common ownership of the vessels rendering and receiving such assistance or salvage services.

The master or person in charge of a vessel shall, so far as he can do so without serious danger to his own vessel, crew, or passengers, render assistance to every person who is found at sea in danger of being lost; and if he fails to do so, he shall, upon conviction, be liable to a penalty of not exceeding $1,000 or imprisonment for a term not exceeding two years, or both.

Salvors of human life, who have taken part in the services rendered on the occasion of the accident giving rise to salvage, are entitled to a fair share of the remuneration awarded to the salvors of the vessel, her cargo, and accessories.

A suit for the recovery of remuneration for rendering assistance or salvage services shall not be maintainable if brought later than two years from the date when such assistance or salvage was rendered, unless the court in which the suit is brought shall be satisfied that during such period there had not been any reasonable opportunity of arresting the assisted or salved vessel within the jurisdiction of the court or within the territorial waters of the country

in which the libelant resides or has his place of business.

Nothing in this Act shall be construed as applying to ships of war or to Government ships appropriated exclusively to a public service.

That hereafter the Secretary of the Navy is authorized to cause vessels under his control adapted to the purpose, to afford salvage service to public or private vessels in distress: Provided, That when such salvage service is rendered by a vessel specially equipped for the purpose or by a tug, the Secretary of the Navy may determine and collect reasonable compensation therefor.

Sand for Fire Purposes.—(See Fire Precautions; Fuel Oil Tanks.)

Sanitary Condition.—It shall be the duty of the master and chief engineer of any vessel under the jurisdiction of the Steamboat Inspection Service to see that such vessel and the passenger and crew's quarters are kept in a sanitary condition. Failure on the part of the master (or chief engineer so far as it applies to the engineers' department) of any vessel to observe and carry into effect this section shall be sufficient cause for the suspension of his license on a charge of inattention to his duties.

Scuppers and Sanitary Pipes.—All scuppers, sanitary and other similar discharges which lead through the ship's hull, shall be fitted with efficient means for preventing the ingress of water in the event of a fracture of such pipes.

The requirements of the above paragraph do not apply to the discharges in the machinery space connected with the main and auxiliary engines, pumps, etc.

All scupper, soil, and sanitary pipes shall be adequately protected; casings to be substantial and so fitted to be conveniently removed for the purpose of examination.

Sea Cocks and Valves.—All sea valves or cocks secured to the skin of the vessels by bolts and connected to the engines or boilers by pipes shall be arranged so as to be accessible at all times, so that if a leak or defect occurs it can be reached. All parts of said valves except the chamber shall be made of brass or bronze when used on wooden-hull vessels navigating salt water; but in the case of vessels of iron or steel the brass or bronze bolts may be dispensed with.

Seamen.—An applicant for examination for certificate of service as able seaman shall be eligible for examination after he has furnished satisfactory documentary evidence that he has had the experience required by law.

Before a certificate may be granted to such applicant he must prove to the satisfaction of the local inspectors, by an oral and written examination, and an actual demonstration, that he has been trained in all the operations connected with launching lifeboats and life rafts, and the use of oars and sail, that he is acquainted with the practical handling of the boats themselves; and, further, that he is capable of taking command of a boat's crew.

The oral examination shall consist of questions regarding the construction of lifeboats and life rafts, the names of their different parts, and a description of the required equipment; clearing away, swinging out, and lowering boats and rafts; handling boats under oars and sail, including questions relative to the proper handling of a boat in running before a heavy sea, in pulling into a sea, etc.; the construction and functions of the gravity, radial, and bar types of davits; knowledge of nautical terms; boxing the compass, by degrees or points, according to the experience of the applicant; a few of the principal knots, bends, splices, and hitches in common use, and also his knowledge in handling the wheel by obeying orders passed to him as "wheelman," and of the use of engine telegraphs or bell-pull signals.

The written examination shall consist of questions regarding the running lights for steam and sailing vessels on the sea, inland waters, or Great Lakes, and fog signals, according to the waters on which the applicant has served; passing signals for vessels meeting or passing under ordinary conditions.

The applicant shall demonstrate his ability by taking command of a boat's crew and directing the operation of clearing away, swinging out, and lowering a boat into the water, and acting as coxswain in charge of the boat under oars and sail. The candidate will also demonstrate his ability to pull an oar.

The certificate and stub shall bear an imprint of the left thumb of the holder on the back thereof.

Searchlight.—Any master or pilot of any steam vessel who shall flash or cause to be flashed the rays of the searchlight in the pilot house of a passing vessel shall be deemed guilty of misconduct and shall be liable to have his license suspended or revoked. (See Motor Lifeboats.)

Shaft.—The outboard shaft or shafts on every ocean or coastwise vessel shall be drawn for examination once at

least in every 3 years; Provided, however, if the circumstances warrant it, the supervising inspector of the district may extend this time to the next regular drydocking period, not to exceed 4 months: Provided, further, That when it is shown that a vessel has had a long period of lay-up, the supervising inspector of the district may grant an extension equal to the time the vessel has been out of commission, but in no case shall the extension exceed 1 year.

Shipment in Foreign Trade.—The master of every vessel bound from a port in the United States to any foreign port other than vessels engaged in trade between the United States and the British North American possessions, or the West India Islands, or the republic of Mexico, or of any vessel of the burden of 75 tons or upward, bound from a port on the Atlantic to a port on the Pacific, or vice versa, shall, before he proceeds on such voyage, make an agreement, in writing or in print, with every seaman whom he carries to sea as one of the crew, in the manner hereinafter mentioned; and every such agreement shall be, as near as may be, in the form given in the table marked "A" (page 67, Navigation Laws of the United States), and shall be dated at the time of the first signature thereof, and shall be signed by the master before any seaman signs the same, and shall contain the following particulars:

1. The nature and, as far as practicable, the duration of the intended voyage or engagement, and the port or country at which the voyage is to terminate.
2. The number and description of the crew, specifying their respective employments.
3. The time at which each seaman is to be on board to begin work.
4. The capacity in which each seaman is to serve.
5. The amount of wages which each seaman is to receive.
6. A scale of the provisions which are to be furnished to each seaman.
7. Any regulations as to conduct on board and as to fines, short allowances of provisions, or other lawful punishments for misconduct, which may be sanctioned by Congress or authorized by the Secretary of Commerce not contrary to or not otherwise provided for by law, which the parties agree to adopt.
8. Any stipulations in reference to allotment of wages, or other matters not contrary to law.

The following rules shall be observed with respect to agreements:

1. Every agreement except such as are otherwise specially provided for, shall be signed by each seaman in the presence of a shipping commissioner.

2. When the crew is first engaged the agreement shall be signed in duplicate, and one part shall be retained by the shipping commissioner, and the other part shall contain a special place or form for the description and signatures of persons engaged subsequently to the first departure of the ship, and shall be delivered to the master.

3. Every agreement entered into before a shipping commissioner shall be acknowledged and certified under the hand and official seal of such commissioner. The certificate of acknowledgment shall be indorsed on or annexed to the agreement; and shall be in the following form:

"State of ——, County of ——;

"On this —— day of ——, personally appeared before me, a shipping commissioner in and for the said county, A. B., C. D., and E. F., severally known to me to be the same persons who executed the foregoing instrument, who each for himself acknowledged to me that he had read or had heard read the same; that he was by me made acquainted with the conditions thereof, and understood the same; and that, while sober and not in a state of intoxication, he signed it freely and voluntarily, for the uses and purposes therein mentioned."

The master shall, at the commencement of every voyage or engagement, cause a legible copy of the agreement, omitting signatures, to be placed or posted up in such part of the vessel as to be accessible to the crew; and on default shall be liable to a penalty of not more than $100.

Shipment in Coastwise Trade.—None of the provisions of an act entitled "An act to authorize the appointment of shipping commissioners by the several circuit courts of the United States to superintend the shipping and discharge of seamen engaged in merchant ships belonging to the United States, and for the further protection of seamen" shall apply to sail or steam vessels engaged in the coastwise trade (except the coastwise trade between the Atlantic and Pacific coasts), or in the lake-going trade touching at foreign ports or otherwise, or in the trade between the United States and the British North American possessions, or in any case where the seamen are by custom

or agreement entitled to participate in the profits or result of a cruise, or voyage.

Shipment in Foreign Ports before Consuls.—Every master of a merchant vessel who engages any seaman at a place out of the United States, in which there is a consular officer, shall, before carrying such seaman to sea, procure the sanction of such officer and shall engage seamen in his presence; and the rules governing the engagement of seamen before a shipping commissioner in the United States shall apply to such engagements made before a consular officer; and upon every such engagement the consular officer shall indorse upon the agreement his sanction thereof, and an attestation to the effect that the same has been signed in his presence and otherwise duly made.

Every master who engages any seaman in any place in which there is a consular officer otherwise than as required by the preceding section shall incur a penalty of not more than $100, for which penalty the vessel shall be held liable.

Every master of a vessel in the foreign trade may engage any seaman at any port out of the United States, in the manner provided by law, to serve for one or more round trips from and to the port of departure, or for a definite time, whatever the destination; and the master of a vessel clearing from a port of the United States with one or more seamen engaged in a foreign port as herein provided shall not be required to reship in a port of the United States the seamen so engaged.

Slop Chest.—Every vessel belonging to a citizen of the United States, bound from a port in the United States to any foreign port, or being of the burden of 75 tons or upward, and bound from a port on the Atlantic to a port on the Pacific, or vice versa, shall be provided with a slop chest, which shall contain a complement of clothing for the intended voyage for each seaman employed, including boots or shoes, hats or caps, under clothing and outer clothing, oiled clothing, and everything necessary for the wear of a seaman; also a full supply of tobacco and blankets. Any of the contents of the slop chest shall be sold, from time to time, to any or every seaman applying therefor, for his own use, at a profit not exceeding 10 per centum of the reasonable wholesale value of the same at the port at which the voyage commenced. And if any such vessel is not provided, before sailing, as herein required, the owner shall be liable to a penalty of not more than $500. The provisions

of this section shall not apply to vessels plying between the United States and the Dominion of Canada, Newfoundland, the Bermuda Islands, the Bahama Islands, the West Indies, Mexico, and Central America.

Smoke Helmet.—All passenger vessels of not less than 200 and not over 1,000 gross tons, excepting vessels certificated as ferry vessels, shall have on board at least one smoke helmet accessible to deck and engine departments, and all vessels of over 1,000 gross tons, excepting vessels certificated as ferry vessels, at least two smoke helmets, one in deck department and one in engine department. The master and chief engineer shall train a sufficient number of officers and crew in their respective departments in the use of these helmets.

Soliciting Lodgers.—If, within 24 hours after the arrival of a vessel at any port in the United States, any person, then being on board such vessel, solicits any seaman to become a lodger at the house of any person letting lodgings for hire, or takes out of such vessel any effects of any seaman, except under his personal direction, and with the permission of the master, he shall, for every such offense, be punishable by a fine of not more than $50, or by imprisonment for not more than three months. This section shall apply to vessels of the United States engaged in the foreign trade and to foreign vessels.

Sounding Pipes.—(See Bilge Pipes.)

Spanners.—(See Fire Pumps and Hose.)

Speaking Tube.—(See Bell Signals.)

Sprinkling System.—(See Water-Sprinkling System.)

Stability.—(See Inclining Test.)

Stairways.—Every steam vessel shall be provided with sufficient means of escape from the lower to the upper deck, or vice versa, and every steamer of 50 tons or over carrying passengers shall be provided with permanent stairways forward and aft, except where said stairways on towing boats would interfere with towing bitts.

Station Bills.—It shall be the duty of the master of every vessel carrying passengers and all other vessels of over 500 gross tons and subject to inspection to cause station bills and muster lists to be prepared before the vessel sails which shall be signed by the master who shall be responsible for their preparation. The station bills and muster lists shall be posted in conspicuous places in several parts of the vessel, particularly in the crew's quarters, and

must contain full particulars of the signals which will be used for calling the crew to their stations for emergency duties. Special duties shall be allotted to each member of the crew and the muster lists shall show all these special duties and indicate the station to which each man must go and the duties he has to perform. The special duties should, as far as possible, be comparable to the regular work of the individual. On passenger vessels where the size of the crew will permit, several members of the crew should be designated as an emergency squad and required to report to the bridge with certain equipment for instructions.

The duties provided for by the muster lists should include:

(a) The closing of airports, watertight doors, fire doors, and fire screens, the covers and all valves of all scuppers, sanitary and other discharges which lead through the ship's hull below the margin line, and stopping the fans and ventilating systems.

(b) The extinction of fire.

(c) The equipment of boats, rafts, and buoyant apparatus and their preparation for launching.

(d) The muster of passengers.

1. Warning the passengers.

2. Seeing that they are dressed and have put on their life jackets in a proper manner.

3. Assembling the passengers and directing them to the appointed stations.

4. Keeping order in the passages and on the stairways and generally controlling the movements of the passengers.

Steam Smothering Lines.—Steam smothering lines shall be tested with at least 50 pounds air pressure with ends of the smothering lines capped, or by blowing steam through the lines, and a survey made for detecting corrosion and defects, using the hammer test or such other means as may be necessary.

Steam Pipes.—It shall be the duty of inspectors when inspecting or reinspecting a vessel to carefully examine all steam pipes passing through woodwork, and if in their judgment the same are deemed unsafe they shall have them provided with air space and fitted with metal collars.

Steam to Holds.—(See Fire Precautions.)

Steam Whistle.—(See Whistle for Steamers.)

Steerage Passengers.—It shall not be lawful for the

master of any vessel whereon steerage passengers have been taken at any port or place in a foreign country or dominion (ports and places in foreign territory contiguous to the United States excepted) to bring such vessel and passengers to or take from any port or place in the United States unless the compartments, spaces, and accommodations hereinafter mentioned have been provided, allotted, maintained, and used for and by such passengers during the entire voyage, unobstructed by cargo, stores, or goods. The master of a vessel coming to a port or place in the United States in violation of any of the provisions of this section shall be deemed guilty of a misdemeanor; and if the number of steerage passengers carried or brought in the vessel, or in any compartment, space, poop, or deck house hereof, is greater than the number allowed to be carried or brought therein, as hereinafter prescribed, the said master shall be fined $50 for each and every such passenger in excess of the proper number, and may also be imprisoned not exceeding six months.

In computing the number of passengers carried or brought in any vessel, children under one year of age shall not be included, and two children between one and eight years of age shall be counted as one passenger; and any person brought in such vessel who shall have been, during the voyage, taken from any other vessel wrecked or in distress on the high seas, or have been picked up at sea from any boat, raft, or otherwise, shall not be included in such computation.

Second: The expression "steerage passenger" means all passengers except cabin passengers, and persons shall not be deemed cabin passengers unless the space allotted to their exclusive use is in the proportion of at least 36 clear superficial feet to each passenger.

Third: The expression "lowest passenger deck" means the deck next below the water line; and the expression "passenger deck" includes every deck or portion of a deck which is above the lowest passenger deck, and is appropriated for passengers.

Fourth: A vessel shall not carry passengers, whether cabin or steerage passengers, on more than one deck below the water line.

Fifth: The height between that part of any deck on which steerage passengers are carried and the deck immediately above it shall not be less than 6 feet.

Sixth: No steerage passengers shall be carried on the lowest passenger deck unless it is efficiently lighted by side scuttles and otherwise to the satisfaction of the inspector.

Seventh: No greater number of steerage passengers shall be carried on the lowest passenger deck than in the proportion of one steerage passenger to every 21 clear superficial feet allotted to their use. If, however, the height between the lowest passenger deck and the deck immediately above it is less than 7 feet, and the apertures, exclusive of side scuttles, through which light and air are admitted are less in size than in the proportion of 3 square feet to every 100 superficial feet of that deck, no greater number of steerage passengers shall be carried on that deck than in the proportion of one steerage passenger to every 30 clear superficial feet thereof, subject to the allowance for measurement of public rooms, lavatories, and bath rooms, if any, provided for by paragraph ten.

Eighth: No greater number of steerage passengers may be carried on a passenger deck than in the proportion of one steerage passenger to every 18 clear superficial feet of deck allotted to their use, subject to the allowance for measurement of public rooms, lavatories, and bath rooms, if any, provided for by paragraph ten. If, however, the height between any passenger deck and the deck immediately above it be less than 7 feet, no greater number of steerage passengers may be carried on that deck than in the proportion of one steerage passenger to every 21 clear superficial feet thereof, subject to the allowance for measurement of public rooms, lavatories, and bath rooms, if any, provided for by paragraph ten.

Ninth: A vessel, whatever be the superficial space of the passenger decks and of the lowest passenger deck, shall not carry a greater number of steerage passengers on the whole than in the proportion of one steerage passenger to every 5 superficial feet of air or promenade space provided on a deck so open as not to be included in the tonnage and approved by the inspector, and this space shall not be counted or included in the area available for any other passengers, or in other areas for steerage passengers prescribed by this section.

Tenth: In the measurement of the passenger decks and of the lowest passenger deck, the space occupied by that part of the personal baggage of the steerage passengers which the inspector permits to be carried there shall be

included, and also, on whatever deck located, commodious and suitable dining rooms, lounging rooms, smoking rooms, lavatories, toilet rooms, and bath rooms: Provided, That:

(*a*) The space in any place appropriated to the use of steerage passengers in which they sleep shall not be less than 18 superficial feet in the case of the lowest passenger deck and 15 superficial feet in the case of a passenger deck.

(*b*) Each space so included in the measurement must be clearly marked to the satisfaction of the inspector as being exclusively appropriated for the use of the steerage passengers.

Eleventh: Each separate compartment in which steerage passengers are berthed shall be conspicuously marked, showing the total area of such compartments.

Berths for Passengers.—In every such steamship or other vessel there shall be a sufficient number of berths for the proper accommodation as hereinafter provided, of all such passengers. There shall not be on any deck nor in any compartment or space occupied by such passengers more than two tiers of berths. The berths shall be properly constructed, and be separated from each other by partitions, as berths ordinarily are separated, and each berth shall be at least two feet in width and six feet in length; and the interval between the floor or lowest part of the lower tier of berths and the deck beneath them shall not be less than six inches, nor the interval between each tier of berths, and the interval between the uppermost tier and the deck above it, less than two feet six inches; and each berth shall be occupied by not more than one passenger over 8 years of age; but double berths of twice the above-mentioned width may be provided, each double berth to be occupied by no more and by none other than two women, or by one woman and two children under the age of 8 years, or by husband and wife, or by a man and two of his own children under the age of 8 years, or by two men personally acquainted with each other. All the male passengers upwards of 14 years of age who do not occupy berths with their wives shall be berthed in the fore part of the vessel, in a compartment divided off from the space or spaces appropriated to the other passengers by a substantial and well-secured bulkhead; and unmarried female passengers shall be berthed in a compartment separated from the spaces occupied by other passengers by a substantial and well-constructed bulkhead, the opening or communication

from which to an adjoining passenger space shall be so constructed that it can be closed and secured. Families, however, shall not be separated except with their consent. Each berth shall be numbered serially, on the outside berth board, according to the number of passengers that may lawfully occupy the berth; and the berths occupied by such passengers shall not be removed or taken down until the expiration of 12 hours from the time of entry, unless previously inspected within a shorter period. For any violation of either of the provisions of this section the master of the vessel shall be liable to a fine of $5 for each passenger carried or brought on the vessel.

Light, Air, and Accommodations for Passengers.—Every such steamship or other vessel shall have adequate provisions for affording light and air to the passenger decks and to the compartments and spaces occupied by such passengers, and with adequate means and appliances for ventilating the said compartments and spaces. To compartments having sufficient space for 50 or more of such passengers at least two ventilators, each not less than 12 inches in diameter, shall be provided, one of which ventilators shall be inserted in the forward part of the compartment and the other in the after part thereof, and shall be so constructed as to ventilate the compartment; and additional ventilators shall be provided for each compartment in the proportion of two ventilators for each additional 50 of such passengers carried or brought in the compartment. All ventilators shall be carried at least six feet above the uppermost deck of the vessel and shall be of the most approved form and construction. In any steamship the ventilating apparatus provided or any method of ventilation adopted thereon, which has been approved by the proper emigration officers at the port or place from which said vessel was cleared, shall be deemed a compliance with the foregoing provisions; and in all vessels carrying or bringing such passengers there shall be properly constructed hatchways over the compartments or spaces occupied by such passengers, which hatchway shall be properly covered with houses or booby hatches, and the combings or sills of which shall rise at least six inches above the deck; and there shall be proper companionways or ladders from each hatchway leading to the compartments or spaces occupied by such passengers; and the said companionways or ladders shall be securely constructed and be

provided with handrails or strong rope, and, when the weather will permit, such passengers shall have the use of each hatchway situated over the compartments or spaces appropriated to their use; and every vessel carrying or bringing such passengers shall have a properly located and constructed caboose and cooking range or other cooking apparatus, the dimensions and capacity of which shall be sufficient to provide for properly cooking and preparing the food of all such passengers. In every vessel carrying or bringing such passengers there shall be at least two water-closets or privies and an additional water-closet or privy for every 100 male passengers on board, for the exclusive use of such male passengers, and an additional water-closet or privy for every 50 female passengers on board, for the exclusive use of the female passengers and young children on board. The aforesaid water-closets and privies shall be properly enclosed and located on each side of the vessel and shall be separated from passengers' spaces by substantial and properly constructed partitions or bulk-heads; and the water-closets and privies shall be kept and maintained in a serviceable and cleanly condition throughout the voyage. For any violation of either of the provisions of this section or for any neglect to conform to the requirements thereof, the master of the vessel shall be liable to a penalty not exceeding $250.

Provisions.—An allowance of good, wholesome, and proper food, with a reasonable quantity of fresh provisions, which food shall be equal in value to one and a half navy rations of the United States, and of fresh water, not less than four quarts per day, shall be furnished each of such passengers. Three meals shall be served daily, at regular and stated hours, of which hours sufficient notice shall be given. If any such passengers shall at any time during the voyage be put on short allowance for food and water, the master of the vessel shall pay to each passenger $3 for each and every day the passenger may have been put on short allowance, except in case of accidents, where the captain is obliged to put the passengers on short allowance. Mothers with infants and young children shall be furnished the necessary quantity of wholesome milk or condensed milk for the sustenance of the latter. Tables and seats shall be provided for the use of passengers at regular meals. And for every willful violation of any of the provisions of this section the master of the vessel shall be deemed guilty

of a misdemeanor and shall be fined not more than $500, and be imprisoned for a term not exceeding six months. The enforcement of this penalty, however, shall not affect the civil responsibility of the master and owners of the vessel to such passengers as may have suffered from any negligence, breach of contract, or default on the part of such master and owners.

Medical Attendance.—In every such steamship or other vessel there shall be properly built and secured, or divided off from other spaces, two compartments or spaces to be used exclusively as hospitals for such passengers, one for men and the other for women. The hospitals shall be located in a space not below the main deck of the vessel. The hospital spaces shall in no case be less than in the proportion of 18 clear superficial feet for every 50 such passengers who are carried or brought on the vessel, and such hospitals shall be supplied with proper beds, bedding, and utensils, and be kept so supplied throughout the voyage. And every steamship or other vessel carrying or bringing emigrant passengers, or passengers other than cabin passengers, exceeding 50 in number, shall carry a duly qualified and competent surgeon or medical practitioner, who shall be rated as such in the ship's articles, and who shall be provided with surgical instruments, medical comforts, and medicines proper and necessary for diseases and accidents incident to sea voyages, and for the proper medical treatment of such passengers during the voyage, and with such articles of food and nourishment as may be proper and necessary for preserving the health of infants and young children; and the services of such surgeon or medical practitioner shall be promptly given, in any case of sickness or disease, to any of the passengers, or to any infant or young child of any such passengers, who may need his services. For a violation of either of the provisions of this section the master of the vessel shall be liable to a penalty not exceeding $250.

Discipline and Cleanliness.—The master of every such steamship or other vessel is authorized to maintain good discipline and such habits of cleanliness among such passengers as will tend to the preservation and promotion of health, and to that end he shall cause such regulations as he may adopt for such purposes to be posted up on board the vessel, in a place or places accessible to such passengers, and shall keep the same posted up during the voyage.

The said master shall cause the compartments and spaces provided for, or occupied by, such passengers to be kept at all times in a clean and healthy condition, and to be, as often as may be necessary, disinfected with chloride of lime, or by some other equally efficient disinfectant. Whenever the state of the weather will permit, such passengers and their bedding shall be mustered on deck, and a clear and sufficient space on the main or any upper deck of the vessel shall be set apart, and so kept, for the use and exercise of such passengers during the voyage. For each neglect or violation of any of the provisions of this section the master of the vessel shall be liable to a penalty not exceeding $250.

Privacy of Passengers.—Neither the officers, seamen, nor other persons employed on any such steamship or other vessel shall visit or frequent any part of the vessel provided or assigned to the use of such passengers, except by the direction or permission of the master of such vessel first made or given for such purpose; and every officer, seaman, or other person employed on board of such vessel who shall violate the provisions of this section shall be deemed guilty of a misdemeanor, and may be fined not exceeding $100, and be imprisoned not exceeding twenty days, for each violation; and the master of such vessel who directs or permits any officer, seaman, or other person employed on board the vessel to visit or frequent any part of the vessel provided for or assigned to the use of such passengers, or the compartments or spaces occupied by such passengers, except for the purpose of doing or performing some necessary act or duty as an officer, seaman, or other person employed on board of the vessel, shall be deemed guilty of a misdemeanor, and may be fined not more than $100 for each time he directs or permits the provisions of this section to be violated. A copy of this section, written or printed in the language or principal languages of the passengers on board, shall, by or under the direction of the master of the vessel, be posted in a conspicuous place on the forecastle and in the several parts of the vessel provided and assigned for the use of such passengers, and in each compartment or space occupied by such passengers, and the same shall be kept so posted during the voyage; and if the said master neglects so to do, he shall be deemed guilty of a misdemeanor, and shall be fined not more than $100.

Explosives; Cattle.—It shall not be lawful to take, carry, or have on board of any such steamship or other vessel any nitroglycerine, dynamite, or any other explosive article or compound, nor any vitriol or like acids, nor gunpowder, except for the ship's use, nor any article or number of articles, whether as a cargo or ballast, which, by reason of the nature or quantity or mode of storage thereof, shall, either singly or collectively, be likely to endanger the health or lives of the passengers or the safety of the vessel; and horses, cattle, or other animals taken on board of or brought in any such vessel shall not be carried on any deck below the deck on which passengers are berthed, nor in any compartment in which passengers are berthed, nor in any adjoining compartment except in a vessel built of iron, and of which the compartments are divided off by watertight bulkheads extending to the upper deck. For every violation of any of the provisions of this section the master of the vessel shall be deemed guilty of a misdemeanor, and shall be fined not exceeding $1,000, and be imprisoned for a period not exceeding one year.

Steering Gear.—(See Examination and Test; Extra Steering Apparatus.)

Storm Oil.—On and after January 1, 1915, ocean vessels of more than 200 gross tons propelled by machinery and navigating the oceans or gulfs shall carry a supply of oil for the purpose of smoothing the sea or quelling the force of the waves in case of emergency or necessity in the following quantities:

Vessels of over 200 and not over 1,000 gross tons, 30 gallons.

Vessels of over 1,000 and not over 3,000 gross tons, 40 gallons.

Vessels of over 3,000 and not over 5,000 gross tons, 50 gallons.

Vessels of over 5,000 gross tons shall carry at least 100 gallons.

This oil shall be accessible and available at all times, and the location of the supply and the means and methods of its distribution shall be determined by the master of the vessel.

Stove.—(See Fire Precautions.)

Stranding.—(See Accident Reports.)

Straw.—(See Hay and Straw.)

Tarpaulins.—(See Hatches; Hay and Straw.)

Telegraph.—(See Examination and Test; Bell Signals.)

Telephone.—On all steamers where the distance is more than 150 feet between perpendiculars of pilot house and forward part of the engine room there shall be communication by means of a telephone between the pilot house and engine room, such telephone to be installed in lieu of a speaking tube.

Trials of Licensed Officers.—*I. Suspension and Revocation of Licenses.*—1. The inspectors shall, when the charges have been duly filed against a licensed officer of vessel, furnish the accused with a copy thereof, setting forth specifically their character and the section of the statutes or the rules of the board that have been violated, and cite him to appear for trial upon a certain day.

2. Subpoenas shall be in the prescribed form, one copy of which shall be furnished each witness.

3. All testimony shall be reduced to writing. The accused shall be permitted to be represented by counsel and to cross-examine witnesses, and in case of exceptions to questions for any cause the inspectors shall note the exceptions in the margin of the deposition. The deposition shall be sworn to before an officer authorized to administer oaths.

4. The accused may have the hearing of the case continued upon the presentation of reasons satisfactory to the board, and the board may, in like manner, continue the hearing from day to day.

5. During the trial the witnesses shall be examined separately, but if the accused is also a witness he shall not be subject to this rule.

6. At any time before the conclusion of the evidence the charge or charges, if being tried on charges, may be amended, notice of said amendment being furnished to the accused of the nature of such amendment, but no amendment shall be permitted after the conclusion of the evidence.

7. Where the witnesses reside in a district other than that in which the accused is being tried, a certified copy of the charges, together with such interrogatories as the inspectors desire to propound, may be forwarded to the inspectors of the district where the witnesses reside, and said inspectors shall examine the witnesses in the same manner as prescribed in section 3 of this rule.

8. The testimony thus taken shall be forwarded to the inspectors investigating the case and read as evidence in

the cause, the same as though such testimony had been taken by the inspectors trying the same.

9. The inspectors shall furnish the accused with a statement in writing of their finding in the premises.

10. A copy of testimony taken at a trial by a board of local inspectors shall be given to the accused or his representative when request for same is made.

II. Appeal to Supervising Inspectors.—1. The supervising inspector, upon notice of an appeal from the decision of the local board, provided said notice of appeal shall be made within 30 days from the date of the decision of the local board, shall give notice in writing to said local board to forward a certified copy of their decision, together with the charges and all evidence in writing on file in their office.

2. The supervising inspector shall then proceed to investigate the case under the same rules prescribed for the trial of the accused by the local board.

3. The testimony taken before the local board may be considered by the supervising inspector for the purpose of determining whether the finding of the local board is justified by the evidence, and he shall have power to remand the same for explanation or correction.

4. Upon the conclusion of the case the supervising inspector shall furnish the appellant with a notice of his finding in like manner as prescribed for local inspectors.

III. Appeal to Supervising Inspector General.—1. The Supervising Inspector General, upon notice of appeal from the decision of the supervising inspector, provided said notice of appeal shall be made within 30 days from the date of the decision of the supervising inspector, shall proceed to review the case under the same procedure as that of the supervising inspector in cases of appeal, and the decision of the Supervising Inspector General in such cases shall, when approved by the Secretary of Commerce, be final.

IV. Publicity in Hearings at Investigations and Trials.—1. All hearings at investigations and trials shall be open to the public generally and to all who may be interested.

2. At such hearings the principals may be represented by counsel, it being understood that questions by counsel at investigations shall be presented through the inspectors hearing the case; and no cross-examination by counsel shall be permitted at investigations.

Trials of Seamen.—Every shipping commissioner shall hear and decide any question whatsoever between a master, consignee, agent, or owner, and any of his crew, which both parties agree in writing to submit to him; and every award so made by him shall be binding on both parties, and shall, in any legal proceedings which may be taken in the matter, before any court of justice, be deemed to be conclusive as to the rights of parties. And any document under the hand and official seal of a commissioner purporting to be such submission or award shall be prima facie evidence thereof.

In any proceeding relating to the wages, claims, or discharge of a seaman, carried on before any shipping commissioner under the provisions of this Title, such shipping commissioner may call upon the owner, or his agent, or upon the master, or any mate, or any other member of the crew, to produce any log books, papers, or other documents in their possession or power, respectively, relating to any matter in question in such proceedings, and may call before him and examine any of such persons, being then at or near the place, on any such matter; and every owner, agent, master, mate, or other member of the crew who, when called upon by the shipping commissioner, does not produce any such books, papers, or documents, if in his possession or power, or does not appear and give evidence, shall, unless he shows some reasonable cause for such default, be liable to a penalty of not more than $100 for each offense; and, on application made by the shipping commissioner, shall be further punished, in the discretion of the court, as in other cases of contempt of the process of the court.

Turpentine.—Oil or spirits of turpentine may be carried on passenger steamers when put up in good metallic vessels or casks or barrels well and securely bound with iron and stowed in a secure part of the vessel.

Unnecessary Lights.—Any master or pilot of any steam vessel who shall authorize or permit the carrying of any light, electric or otherwise, not required by law, on the outside structure of the cabin or hull of the vessel that in any way interferes with distinguishing the signal lights shall, upon conviction thereof before any board of inspectors having jurisdiction, be deemed guilty of misconduct and shall be liable to have his license suspended or revoked.

Unnecessary Whistles.—Unnecessary sounding of the

steam whistle is prohibited within any harbor limits of the United States. Whenever any licensed officer in charge of any steamer authorizes or permits such unnecessary whistling, upon conviction thereof before any board of inspectors having jurisdiction, such officer shall be suspended from acting under his license as the inspectors trying the case may deem proper.

Unseaworthy Vessels.—If any person knowingly sends or attempts to send or is party to the sending or attempting to send an American ship to sea in the foreign or coastwise trade in such an unseaworthy state that the life of any person is likely to be thereby endangered, he shall in respect of each offense be guilty of a misdemeanor, and shall be punished by a fine not to exceed $1,000 or by imprisonment not to exceed five years, or both, at the discretion of the court, unless he proves that either he used all reasonable means to insure her being sent to sea in a seaworthy state or that her going to sea in an unseaworthy state was, under the circumstances, reasonable and justifiable, and for the purposes of giving that proof he may give evidence in the same manner as any other witness.

Vessels of the United States.—Vessels registered pursuant to law and no others, except such as shall be duly qualified according to law for carrying on the coasting or fishing trade, shall be deemed vessels of the United States and entitled to the benefits and privileges appertaining to such vessels; but no such vessel shall enjoy such benefits and privileges longer than it shall continue to be wholly owned by a citizen or citizens of the United States or a corporation created under the laws of any of the States thereof, and be commanded by a citizen of the United States. And all the officers of vessels of the United States who shall have charge of a watch, including pilots, shall in all cases be citizens of the United States.

Wages.—No seaman shall, by any agreement other than is provided by this Title, forfeit his lien upon the ship, or be deprived of any remedy for the recovery of his wages to which he would otherwise have been entitled; and every stipulation in any agreement inconsistent with any provision of this Title, and every stipulation by which any seaman consents to abandon his right to his wages in the case of the loss of the ship, or to abandon any right which he may have or obtain in the nature of salvage, shall be wholly inoperative.

The following rules shall be observed with respect to the settlement of wages:

1. Upon the completion, before a shipping commissioner, of any discharge and settlement, the master or owner and each seaman, respectively, in the presence of the shipping commissioner, shall sign a mutual release of all claims for wages in respect of the past voyage or engagement, and the shipping commissioner shall also sign and attest it, and shall retain it in a book to be kept for that purpose, provided both the master and seaman assent to such settlement, or the settlement has been adjusted by the shipping commissioner.

2. Such release, so signed and attested, shall operate as a mutual discharge and settlement of all demands for wages between the parties thereto, on account of wages, in respect of the past voyage or engagement.

3. A copy of such release, certified under the hand and seal of such shipping commissioner to be a true copy, shall be given by him to any party thereto requiring the same, and such copy shall be receivable in evidence upon any future question touching such claims, and shall have all the effect of the original of which it purports to be a copy.

4. In cases in which discharge and settlement before a shipping commissioner are required, no payment, receipt, settlement, or discharge otherwise made shall operate as evidence of the release or satisfaction of any claim.

5. Upon payment being made by a master before a shipping commissioner, the shipping commissioner shall, if required, sign and give to such master a statement of the whole amount so paid; and such statement shall, between the master and his employer, be received as evidence that he has made the payments therein mentioned.

Upon every discharge effected before a shipping commissioner, the master shall make and sign, a report of the conduct, character, and qualifications of the persons discharged; or may state in such form that he declines to give any opinion upon such particulars, or upon any of them; and the commissioner shall keep a register of the same, and shall, if desired so to do by any seaman, give to him or endorse on his certificate of discharge a copy of so much of such report as concerns him.

A seaman's right to wages and provisions shall be taken to commence either at the time at which he commences work, or at the time specified in the agreement for his com-

mencement of work or presence on board, whichever first happens.

No right of wages shall be dependent on the earning of freight by the vessel; but every seaman or apprentice who would be entitled to demand and receive any wages if the vessel on which he has served had earned freight shall, subject to all other rules of law and conditions applicable to the case, be entitled to claim and recover the same of the master or owner in person, notwithstanding that freight has not been earned. But in all cases of wreck or loss of vessel, proof that any seaman or apprentice has not exerted himself to the utmost to save the vessel, cargo, and stores shall bar his claim.

In cases where the service of any seaman terminates before the period contemplated in the agreement, by reason of the loss or wreck of the vessel, such seaman shall be entitled to wages for the time of service prior to such termination, but not for any further period. Such seaman shall be considered as a destitute seaman and shall be treated and transported to port of shipment as provided by law.

Any seaman who has signed an agreement and is afterward discharged before the commencement of the voyage or before one month's wages are earned, without fault on his part justifying such discharge, and without his consent, shall be entitled to receive from the master or owner, in addition to any wages he may have earned, a sum equal in amount to one month's wages as compensation and may, on adducing evidence satisfactory to the court hearing the case of having been improperly discharged, recover such compensation as if it were wages duly earned.

No seaman or apprentice shall be entitled to wages for any period during which he unlawfully refuses or neglects to work when required, after the time fixed by the agreement for him to begin work, nor, unless the court hearing the case otherwise directs, for any period during which he is lawfully imprisoned for any offense committed by him.

The master or owner of any vessel making coasting voyages shall pay to every seaman his wages within two days after the termination of the agreement under which he has shipped, or at the time such seaman is discharged, whichever first happens; and in cases of vessels making foreign voyages, or from a port on the Atlantic to a port on the Pacific, or vice versa, within 24 hours after the cargo

has been discharged, or within four days after the seaman has been discharged, whichever first happens; and in all cases the seaman shall be entitled to be paid at the time of his discharge on account of his wages a sum equal to one-third part of the balance due him. Every master or owner who refuses or neglects to make payment in the manner hereinbefore mentioned without sufficient cause shall pay to the seaman a sum equal to two days' pay for each and every day during which payment is delayed beyond the respective periods, which sum shall be recoverable as wages in any claim made before the court; but this section shall not apply to masters or owners of any vessel the seaman of which are entitled to share in the profits of the cruise or voyage.

Every seaman on a vessel of the United States shall be entitled to receive on demand from the master of the vessel to which he belongs one-half part of the balance of his wages earned and remaining unpaid at the time when such demand is made at every port where such vessel, after the voyage has been commenced, shall load or deliver cargo before the voyage is ended, and all stipulations in the contract to the contrary shall be void: Provided, Such a demand shall not be made before the expiration of, nor oftener than once in five days nor more than once in the same harbor on the same entry. Any failure on the part of the master to comply with this demand shall release the seaman from his contract and he shall be entitled to full payment of wages earned. And when the voyage is ended every such seaman shall be entitled to the remainder of the wages which shall be then due him: Provided further, That notwithstanding a release signed by a seaman any court having jurisdiction may upon good cause shown set aside such release and take such action as justice shall require: And provided further, That this section shall apply to seamen on foreign vessels while in harbors of the United States, and the courts of the United States shall be open to such seaman for its enforcement.

Whenever the wages of any seaman are not paid within ten days after the time when the same ought to be paid according to the provisions of this Title, or any dispute arises between the master and seamen touching wages, the district judge for the judicial district where the vessel is, or in case his residence be more than three miles from the place, or he be absent from the place of his residence, then,

any judge or justice of the peace, or any commissioner of a district court, may summon the master of such vessel to appear before him, to show cause why process should not issue against such vessel, her tackle, apparel, and furniture, according to the course of admiralty courts, to answer for the wages.

If the master against whom such summons is issued neglects to appear, or, appearing, does not show that the wages are paid or otherwise satisfied or forfeited, and if the matter in dispute is not forthwith settled, the judge or justice or commissioner shall certify to the clerk of the district court that there is sufficient cause of complaint whereon to found admiralty process; and thereupon the clerk of such court shall issue process against the vessel. In all cases where the matter in demand does not exceed $100 the return day of the monition or citation shall be the first day of a stated or special session of court next succeeding the third day after the service of the monition or citation, and on the return of process in open court, duly served, either party may proceed therein to proofs and hearing without other notice, and final judgment shall be given according to the usual course of admiralty courts in such cases. In such suits all the seamen having cause of complaint of the like kind against the same vessel may be joined as complainants, and it shall be incumbent on the master to produce the contract and log book, if required to ascertain any matter in dispute; otherwise the complainants shall be permitted to state the contents thereof, and the burden of proof of the contrary shall be on the master. But nothing herein contained shall prevent any seaman from maintaining any action at common law for the recovery of his wages, or having immediate process out of any court having admiralty jurisdiction wherever any vessel may be found, in case she shall have left the port of delivery where her voyage ended before payment of the wages, or in case she shall be about to proceed to sea before the end of the ten days next after the day when such wages are due.

Moneys paid under the laws of the United States by direction of consular officers or agents at any foreign port or place as wages, extra or otherwise, due American seamen shall be paid in gold or its equivalent, without any deduction whatever, any contract to the contrary notwithstanding.

Any question concerning the forfeiture of, or deductions

from, the wages of any seaman or apprentice may be determined in any proceeding lawfully instituted with respect to such wages, notwithstanding the offense in respect of which such question arises, though hereby made punishable by imprisonment as well as forfeiture, has not been made the subject of any criminal proceeding.

Whenever in any proceeding relating to seaman's wages it is shown that any seaman or apprentice has, in the course of the voyage, been convicted of any offense by any competent tribunal, and rightfully punished therefor, by imprisonment or otherwise, the court hearing the case may direct a part of the wages due to such seaman, not exceeding $15, to be applied in reimbursing any costs properly incurred by the master in procuring such conviction and punishment.

Courts of the United States shall be open to seamen, without furnishing bonds or prepayment of or making deposit to secure fees or costs, for the purpose of entering and prosecuting suit or suits in their own name and for their own benefit for wages or salvage and to enforce laws made for their health and safety.

Advances and Allotments of Wages.—(*a*) It shall be, and is hereby, made unlawful in any case to pay any seaman wages in advance of the time when he has actually earned the same, or to pay such advance wages, or to make any order, or note, or other evidence of indebtedness therefor to any other person, or to pay any person, for the shipment of seamen when payment is deducted or to be deducted from a seaman's wages. Any person violating any of the foregoing provisions of this section shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by a fine of not less than $25 nor more than $100, and may also be imprisoned for a period not exceeding six months, at the discretion of the court. The payment of such advance wages or allotment, whether made within or without the United States or territory subject to the jurisdiction thereof, shall in no case except as herein provided absolve the vessel or the master or the owner thereof from the full payment after the same shall have been actually earned, and shall be no defense to a libel suit or action for the recovery of such wages. If any person shall demand or receive, either directly or indirectly, from any seaman or other person seeking employment, as seaman, or from any person on his behalf, any remuneration whatever for pro-

viding him with employment, he shall for every such offense be deemed guilty of a misdemeanor, and shall be imprisoned not more than six months or fined not more than $500.

(*b*) It shall be lawful for any seaman to stipulate in his shipping agreement for an allotment of any portion of the wages he may earn to his grandparents, parents, wife, sister, or children.

(*c*) No allotment shall be valid unless in writing and signed by and approved by the shipping commissioner. It shall be the duty of the said commissioner to examine such allotments and the parties to them and enforce compliance with the law. All stipulations for the allotment of any part of the wages of a seaman during his absence which are made at the commencement of the voyage shall be inserted in the agreement and shall state the amounts and times of the payments to be made and the persons to whom the payments are to be made.

(*d*) No allotment except as provided for in this section shall be lawful. Any person who shall falsely claim to be such relation, as above described, of a seaman under this section shall for every such offense be punished by a fine not exceeding $500 or imprisonment not exceeding six months, at the discretion of the court.

(*e*) This section shall apply as well to foreign vessels while in waters of the United States as to vessels of the United States, and any master, owner, consignee, or agent of any foreign vessel who has violated its provisions shall be liable to the same penalty that the master, owner, or agent of a vessel of the United States would be for similar violation.

The master, owner, consignee, or agent of any vessel of the United States, or of any foreign vessel seeking clearance from a port of the United States, shall present his shipping articles at the office of clearance, and no clearance shall be granted any such vessel unless the provisions of this section have been complied with.

Wages and Clothing Exempt from Attachment.—No wages due or accruing to any seaman or apprentice shall be subject to attachment or arrestment from any court, and every payment of wages to a seaman or apprentice shall be valid in law, notwithstanding any previous sale or assignment of wages or of any attachment, encumbrance, or arrestment thereon; and no assignment or sale of wages or of salvage made prior to the accruing thereof shall bind

the party making the same, except such allotments as are authorized by this title. This section shall apply to fishermen employed on fishing vessels as well as to seamen: Provided, That nothing contained in this or any preceding section shall interfere with the order by any court regarding the payment by any seaman of any part of his wages for the support and maintenance of his wife and minor children.

The clothing of any seaman shall be exempt from attachment, and any person who shall detain such clothing when demanded by the owner shall be deemed guilty of a misdemeanor, and shall be imprisoned not more than six months or fined not more than $500, or both.

No sum exceeding one dollar shall be recoverable from any seaman by any one person for any debt contracted during the time such seaman shall actually belong to any vessel until the voyage for which such seaman engaged shall be ended.

Warmth and Clothing.—Every vessel bound on any foreign voyage exceeding in length 14 days shall be provided with at least one suit of woolen clothing for each seaman, and every vessel in the foreign or domestic trade shall provide a safe and warm room for the use of seamen in cold weather. Failure to make such provision shall subject the owner or master to a penalty of not less than $100.

Watchmen.—(See Look-outs and Watchmen.)

Water Lights.—The self-igniting water lights for ring buoys and life rafts shall consist of a cylinder (with bumped heads or ends) made of good sheet copper of not less than 0.022 inch thick, and shall be so designed as to be non-explosive, and shall be free from any defects which may affect the serviceability or operation of the light. The cylinder shall be sufficiently weighted in the bottom to recover and maintain an upright position in the water, and all circumferential and horizontal seams of the cylinder shall be hook-jointed and soldered, and the top circumferential seam shall be flush, so as to prevent the lodgment of water.

The cylinder shall be provided with a plug or other device of such character that when removed from the cylinder sufficient water will be admitted to insure the prompt and efficient action of the light, regardless of whether the cylinder when first striking the water becomes completely submerged.

The removal of the plug or device shall be effected by

the operation of a lanyard attached to the buoy and to the plug or device on the cylinder, and shall be so arranged and constructed that the weight of the buoy when thrown overboard will automatically disengage the plug or device, and will insure that the light will self-ignite within one minute after reaching the surface of the water: Provided, That on oil-tank steamers the self-igniting water light need not be attached to the ring buoy, but may be placed alongside the buoy which it is intended to serve, so that it can be easily and quickly attached to the buoy by means of its lanyard when needed in case of emergency.

On oil-tank steamers, when self-igniting water lights are not attached to the ring buoys, a snap hook shall be provided for this purpose.

The cylinder shall contain calcium carbide (taken from fresh stock entirely free from the white powdery substance resulting from exposure to the air) and calcium phosphide sufficient to create a brilliant flame of at least 150 candlepower, which shall be maintained and burn for a continuous period of not less than 45 minutes without emitting obnoxious fumes. If at any time during this period the flame is extinguished, due to the total submersion of the light, the light shall self-ignite upon coming to the surface.

The self-igniting water lights required for life rafts shall meet the above requirements, except that the plug or device may be removed by manual action instead of by automatic action of the buoy lanyard above referred to.

The cylinder shall be plainly marked with the word "Top" at its top end and permanently indented or embossed with the name and address of the manufacturer (the use of labels of any description for this purpose is strictly forbidden), and with the statement that the device meets in every way the requirements of the Board of Supervising Inspectors.

On and after July 1, 1924, no type or make of water light will be approved which has not been tested by the Bureau of Standards, Department of Commerce, and found to conform in all respects to these requirements.

These rules for water lights shall be effective on and after July 1, 1924.

Provided, That water lights manufactured before April 1, 1924, and installed on vessels previous to the application of the present requirements will be allowed to remain in service so long as they are maintained in good and service-

able condition; and inspectors, when inspecting vessels having such water light equipment, shall give especial attention to the condition of the water lights, and if there appears any evidence whatsoever of corrosion, such as blisters and warts under the paint, or where the can is badly abrased by hard usage or carelessness, the same must be condemned at once and new water lights of an approved type substituted for the ones so condemned, and the attention of the officers of the vessel must then be called to the necessity for greater care to be exercised in the preservation of the equipment, and it must be made clear to them that they will be held strictly accountable to this service for the condition of the same.

Water-sprinkling System.—On and after December 31, 1916, all steamers carrying passengers, and which also carry freight upon the main deck which is accessible to passengers or crew while being navigated, shall have installed in such main-deck freight space an efficient overhead water-sprinkling system.

The crew and passenger sleeping accommodations located below the main deck on steamers engaged in the passenger traffic shall have installed therein an efficient overhead water-sprinkling system, unless such quarters and the bed frames therein are constructed of metallic or noncombustible material, thereby making them practically fireproof.

On steamers carrying passengers where the kitchens or galleys are located below the main deck, there shall be installed in such kitchens or galleys an efficient overhead water-sprinkling system. This paragraph shall become effective July 1, 1917.

The water-sprinkling system above referred to shall be reliable and efficient and so located that the volume of discharge shall be sufficient to cover entirely or blanket the freight in case of fire, and to entirely and fully sprinkle the compartment in which the passengers or crew may be accommodated below deck, and be installed in such manner as to be easily and quickly accessible of operation, and shall be ready for service at all times when freight or passengers are on board. The operating valves for the sprinkling system shall be suitably marked.

Weights and Measures.—Every master shall keep on board proper weights and measures for the purpose of determining the quantities of the several provisions and

articles served out, and shall allow the same to be used at the time of serving out such provisions and articles, in the presence of a witness, whenever any dispute arises about such quantities, and in default shall, for every offense, be liable to a penalty of not more than $50.

Whistle for Motor Vessels.—Inspected motor vessels shall be provided with an efficient whistle sounded by steam or by some substitute for steam to give the necessary whistle signals.

Whistle for Steamers.—All steam whistles shall be placed not less than 6 feet above the top of the pilot house of steam vessels where the height of the smokestack will admit the attachment of same below its top, when not hinged for passing under bridges, except upon steamers navigating the Red River of the North, Yukon and similar rivers, and rivers whose waters flow into the Gulf of Mexico, and steamers of less than 100 gross tons, whose steam whistles shall be placed not less than 2 feet above the tops of their pilot houses; and all double-end ferry steamers, and steamers similarly constructed, shall have a steam whistle both fore and aft of the smokestack, or one steam whistle on either the starboard or port side of the smokestack, so that the steam, when whistle is blown, can be seen from either end of steamer; and it shall be the duty of inspectors to enforce this rule at the annual inspection.

It shall also be the duty of the inspectors to compel all floating structures, such as steam elevators (propelled by their own motive power), to have their whistles located on the front side of such superstructures having an elevation higher than the pilot house of the vessels.

Wireless Ship Act.—It shall be unlawful for any steamer of the United States or of any foreign country navigating the ocean or the Great Lakes and licensed to carry, or carrying, fifty or more persons, including passengers or crew or both, to leave or attempt to leave any port of the United States unless such steamer shall be equipped with an efficient apparatus for radio communication, in good working order, capable of transmitting and receiving messages over a distance of at least one hundred miles, day or night. An auxiliary power supply, independent of the vessel's main electric power plant, must be provided which will enable the sending set for at least four hours to send messages over a distance of at least 100 miles, day or night,

and efficient communication between operator in the radio room and the bridge shall be maintained at all times.

The radio equipment must be in charge of two or more persons skilled in the use of such apparatus, one or the other of whom shall be on duty at all times while the vessel is being navigated. Such equipment, operators, the regulation of their watches, and the transmission and receipt of messages, except as may be regulated by law or international agreement, shall be under the control of the master, in the case of a vessel of the United States; and every willful failure on the part of the master to enforce at sea the provisions of this paragraph as to equipment, operators, and watches shall subject him to a penalty of $100.

The provisions of this section shall not apply to steamers plying between ports, or places, less than 200 miles apart.

This Act, so far as it relates to the Great Lakes, shall take effect on and after April 1, 1913, and so far as it relates to ocean cargo steamers shall take effect on and after July 1, 1913: Provided, That on cargo steamers, in lieu of the second operator provided for in this Act, there may be substituted a member of the crew or other person who shall be duly certified and entered in the ship's log as competent to receive and understand distress calls or other usual calls indicating danger, and to aid in maintaining a constant wireless watch so far as required for the safety of life.

For the purpose of this Act apparatus for radio communication shall not be deemed to be efficient unless the company installing it shall contract in writing to exchange, and shall, in fact, exchange, as far as may be physically practicable, to be determined by the master of the vessel, messages with shore or ship stations using other systems of radio communication.

The master or other person being in charge of any such vessel which leaves or attempts to leave any port of the United States in violation of any of the provisions of this Act shall, upon conviction, be fined in a sum not more than $5000, and any such fine shall be a lien upon such vessel, and such vessel may be libeled therefor in any district court of the United States within the jurisdiction of which such vessel shall arrive or depart, and the leaving or attempting to leave each and every port of the United States shall constitute a separate offense.

Part III

DEFINITIONS USED IN SHIP STABILITY AND QUESTIONS AND ANSWERS IN STEEL HULL CONSTRUCTION

Stability.—The power of a floating vessel to return to the upright when inclined.

Freeboard.—Is to ensure that a loaded ship shall have a sufficient height of deck above water from the point of view of weatherliness, and for a safe margin of stability.

Forces Acting Upon a Vessel.—Force of gravity due to its weight acting downwards from the centre of gravity, and the force of buoyancy acting upwards through the centre of buoyancy.

Buoyancy.—The upward component of all the water pressure acting on the surface of a submerged body. It is the force that supports floating bodies and prevents them from sinking.

Displacement Tonnage.—The weight of water displaced by the vessel, or the weight of the vessel with everything on board.

Coefficient of Fineness.—The ratio or proportion that a vessel's under-water form bears to a rectangular block of the same length, breadth, and depth.

Moment of Inertia.—The moment of inertia of a body or area is the measure of its capacity to resist a change of form or position, or its power to remain dead still, when at rest, against a disturbing influence.

Radius of Gyration.—The radius of gyration of a vessel about her rolling axis is the distance from the axis to the position where all the forces due to the moment of inertia of the vessel are concentrated.

Meta Centre.—A position on the middle line of a vessel where all lines drawn vertically upwards from the centres of buoyancy at small angles of heel, meet at a point.

Centre of Gravity.—The centre of all the weight of a body. It is that point in a body, through which, if we insert an axle, the body would have no inclination to turn in any direction, the weight on all sides of the axle being equal. It alters according to the disposition of weights placed on board. If a weight be placed on board above the centre of

gravity that point will rise, and if placed below it will move downwards.

Centre of Buoyancy.—The geometrical centre of the submerged part of the vessel.

Righting Moment.—A ship, when inclined from the upright position, is said to have a Moment tending either to bring her again to the upright position or to increase her inclination, and a rotating movement is induced. The former is usually termed a righting moment and the latter an upsetting or capsizing moment.

Q. What is the boss plate?

A. The plates around the shaft boss.

Q. How are beams riveted, and to what?

A. Beams are riveted to the deck plates and to brackets that connect them to the frame.

Q. How is a bar keel fastened to the sternpost?

A. Bar keel is scarphed to extension on stern frame and riveted.

Q. Describe a water-tight bulkhead.

A. Plating to be not less than $\frac{1}{4}''$ thick, and to have stiffeners not over 2 feet centres, with joints calked. Bulkheads are always extended to shell of vessel and connected thereto with double frame angles. Except in double bottoms they are attached to latter by means of double angles and a water-tight frame fitted below each bulkhead. Plates of bulkheads are usually arranged transversely, but sometimes longitudinally. Spacing of rivets in butts and seams must be such as to permit calking of joints. Vertical stiffeners spaced 30″ on one side, and horizontal stiffeners 48″ opposite side. Wrought iron angle collars to be used where keelson and stringers run through same, all calked.

Q. What is a butt strap?

A. A plate covering joints or butts where two plates come together and riveted to both.

Q. What are deck stringers?

A. Plates placed fore and aft at outboard edges of deck and fastened to deck beams and hull plating. Where there is not a continuous iron deck, deck stringers are placed in-board on deck beams and alongside hatches on beams.

Q. What are floors and how fastened?

A. Vertical plating placed on every frame in bilge of vessel and fastened to frame angles and reverse angles by

rivets, and to keelson plates by an angle clip, which are riveted to floor and keels on plates.

Q. What are floor clips?

A. Angle clips which are riveted to the floors and keelson plate to hold them together.

Q. What is longitudinal framing?

A. Framing which includes all girder forms of material running fore and aft, whose functions perform longitudinal strength, and which are connected to transverse framing.

Q. What is transverse framing?

A. Embraces all girder forms which cross the longitudinal frame work of vessel at right angles affording transverse strength. The strongest form of construction is obtained only where the two systems have been worked together. Web frames are used to take the place of stanchions.

Q. What are gusset plates?

A. Triangular plates placed between adjacent parts for connecting, as for panting beams to side stringers.

Q. What is a garboard strake?

A. Outside shell plating fastened to bar keel on each side, and is thicker than the other strakes of shell plating.

Q. What are intercostals?

A. Plates fastened to the floors at right angles, and also fastened to the assistant keelsons, and sometimes to the shell. They give longitudinal strength.

Q. What is Isherwood system?

A. Longitudinal framing combined with deep webs spaced about every 10 feet.

Q. What is the difference between a plate keel and a bar keel?

A. Plate keel is a heavy single plate laid on its flat and fastened to keelson by clips and made continuous by overlapping.

Bar keel is a bar on its edge made continuous by scarphing and fastened to garboard strake on each side. The flange of garboard is riveted on each side of bar keel.

Q. What is a liner?

A. A liner or shim is a piece of metal or other substance used to fill in where necessary the space between adjoining parts.

Q. What is the difference between keelsons, stringers and assistant keelsons?

A. For longitudinal strength we find along the bottom,

along the bilge and up the side a number of girders of various forms extending fore and aft. Those along the centre line and on the bottom are keelsons. Those along the side above the bilge are stringers or side stringers. The assistant keelsons are comprised of plates fitted intercostally between the floors in a continuous line fore and aft, connected to the floors, shell, and tank tops by angles and clips. The keelson is fitted with intercostal plates between floors similar to the assistant keelson and stands on top of keel at the middle line. It is composed of a vertical plate with two large angles at the top and two at the bottom. The thick plate which mounts it is called the rider plate.

Q. How do you test rivets?

A. By tapping rivet head with a small hammer and feeling with fingers at the same time.

Q. What are lightening holes?

A. Holes cut to lighten plates. Also in floors for accessible purposes in double bottoms.

Q. What is a margin plate?

A. It is a form of intercostal plate connected to floors, shell and tank tops and made watertight, and is out-board edge plate of double bottom.

Q. What is an oxter plate?

A. Oxter plate is the hull plating fastening to the stern frame, and upper part of arch in a steamer.

Q. What is a horse shoe plate?

A. The outside hull plate around the rudder-post and through which the rudder stock passes. It is fastened to the plates and frame adjoining.

Q. Describe joggle—in and out—flush plating.

A. Joggle plating is plates overlapping each other, the outer plate butt being bent (or joggled) to make a fair landing on the butt of the other and to make a fair landing on the beams, this is done to eliminate liners. In-and-out plating is two plates laid fair over the beams with the intervening plate laid on top and fastened to the other two, this form of plating requires a liner laid over the beams under each intervening plate.

Flush plating is laying butts together without lapping on the beams, and connecting the butts with butt straps.

Q. Is a ship's plating all the same thickness? Name heaviest plates.

A. No, the sheer strake, bilge strake and garboard strake

are thicker or doubled, and in a flat plate keel they are also much heavier but are not called garboards.

Q. What are reverse bars?

A. Reverse bars are angle bars riveted to frames on their in-board edge, and are used to stiffen frames and riveting tank tops, too. Also cargo battens are bolted to them.

Q. What is a rider plate?

A. A plate placed on its flat over frame or keelson to which it is riveted, and sometimes supports stanchions.

Q. Describe shell plating.

A. This is the outside plating of the hull or body of the vessel, and it covers and is fastened to the frames of the vessel, and its plates are fastened to each other.

Q. What are stringers?

A. These are two angle bars riveted back to back and fastened to frames at side of ship with lugs or clips. There are several on each side and extend in a fore-and-aft direction to give longitudinal strength and stiffen and hold frames in position.

Q. What strake of deck plating is laid first?

A. The margin strake is laid first to permit the other strakes to be properly butted and laid to it.

Q. What are tie plates?

A. These are plates riveted to adjoining parts to tie them together and are laid fore-and-aft. Usually on deck beams when wood decks are laid in a steel ship, diagonal tie plates are laid diagonally.

Q. What are pillars?

A. Pillars unite the beams and keelsons at centre line preserving the relative distance between the opposite parts, causing them to act as both struts and ties. They are also needed to support the various loads such as deck cargoes, deck houses, winches, etc.

Q. Describe how butts of frames and reverse frames are fastened.

A. Butts of frames and reverse frames are joined at the centre line directly over the keel. To unite the ends of the frame a piece of angle iron about 3 feet long called a heel piece and of same thickness of frame is fitted on the opposite side of the floor and covering the butt. Also on the opposite side to the reverse bar is fitted a short covering piece called a lug.

Q. What does transverse framing consist of?

A. Transverse framing consists of frame bar, reverse frame bar, floor plate, a beam and a pillar or stanchion.

Q. **Describe a cellular double bottom.**

A. The principal part of a cellular double bottom which extends from margin to margin plate is called the ballast tanks. These tanks are divided into port and starboard with a watertight centre thru plate and extends from keel to top of floors, and is also divided transversely with watertight bulkheads. The floors are connected to centre thru plates by heavy angles or lugs. The outer ends or extremities of the floors in bilges called bracket plates extend to the same height around the bilge as floors in ships with ordinary floors. The margin plate, or outer end of the cellular double bottom is turned down at about right angles to the bilge and is riveted watertight to the shell plating with a continuous angle bar which necessitates a break in the continuity of the frame bar. The bracket bar is fitted to margin plate by means of angles and to the frame bar and reverse frame bar with angles.

Q. **Centre thru plate, where located?**

A. A centre thru plate is a heavy deep plate extending continuously along the middle line and standing on a plate keel, and is only used with a plate keel. The depth of the floor is regulated by the depth of this plate. Two large angles are on the top and bottom, and the top is mounted by a thick plate forming part of the tank top, which altogether completes the combination of a centre thru keelson.

Q. **Beam brackets?**

A. Beam brackets are usually triangular plates riveted to the back of the vertical flange of a beam and fit and rivet to the bosom of the frame.

Q. **Half beams—how connected—where used?**

A. They are connected to the hatch coverings by means of angle collars which are heavy enough to support the weight of beams.

Q. **What is the important part in construction of pillars?**

A. Great care should be taken to have the heads and heel pieces constructed heavy enough to stand the full efficiency of the pillars when under heavy stresses.

Q. **How are stringers fastened to the stern?**

A. They are fastened to stern from opposite sides by "V" shaped gusset plates called breast-hooks, or crutches.

Q. Give a general description of the web frame form of construction.

A. This system is similar to the deep frame construction in that the frame-work is so strengthened as to render the two sides self supporting and dispense with hold beams, but instead of uniformly increasing the strength of every frame, only every fifth or sixth frame is increased, but in a very large proportion by means of a deep web plate transformed from a comparatively flexible bar into a strong and rigid girder. The size and distance apart of these frames are governed by the depth of hold and are usually about ten feet apart. A web frame consists of a web of plating fifteen inches wide extending from the tank side to the upper part of the deck beams. It is attached to the shell plating by angles of ordinary frame size and has two smaller reverse angles fitted on its inner edge, or a single reverse angle bar of larger size. In this case the tank bracket knee should be of extra depth and the beam knees to the lower tier of beams should be three times the depth of beam. Web frames are often used where side cargo ports are used, also where beams are cut for hatches and in the engine and boiler space.

Q. What prevention is made for panting?

A. The provisions usually made against panting is the introduction of one or two additional tiers of beams in the fore-peak, and two or more beams in the fore-hold abaft the collision bulkhead. These beams are called panting beams and are fastened to the side stringers with triangular plates called gusset plates.

Q. Describe the framing of a hatch.

A. At all hatch ends an extra strong beam is fitted from frame to frame, consisting of a bulb plate and angle. At the hatch ends the coaming plate or head ledge is carried over this beam to the top of the bulb and securely riveted to the beam with a double row of rivets. The sides of fore-and-aft coamings are carried down well over the ends of all beams or flanged around the bottom of half beams, and the corners of coamings are all riveted together with angle bars. The outside of coamings is made watertight by riveting an angle bar to coamings and deck, angle bar being well calked. Large hatches carry brackets fitted to the coamings on their

inner fore and aft sides, into which are fitted strong-backs for bracing the whole hatch.

Q. What is a locking plate?

A. A locking plate is fitted over one of the pintles to prevent the rudder from un-shipping.

Q. What are mast partners?

A. These are plates fitted between beams to strengthen around the mast wedging.

Q. Explain propeller connection to shaft.

A. A propeller is connected to shaft by being keyed on there in a groove at the end of the shaft and a groove in the boss. The boss is driven on the shaft and a flat key which fits the groove in shaft and boss is inserted.

Q. How is propeller secured to shaft?

A. It is secured with a large nut screwed on the end of the shaft the opposite way to which the propeller revolves when going ahead. The nut is secured by a pin passing thru it and shaft.

Q. What is a thrust block?

A. It is a block which the shaft passes thru and receives the pressure from the propeller when forcing the ship ahead or astern. It is abaft the engine.

Q. Describe the difference in twin screws.

A. The starboard one is the right-handed, and the port one is left-handed, when engine is going ahead.

Q. What are the weights of various size plates in square feet?

A. 1″ plating = 40 pounds per square foot.
$\frac{1}{2}$″ " = 20 " " " "
$\frac{1}{4}$″ " = 10 " " " "
$\frac{1}{8}$″ " = 5 " " " "

Q. Describe cargo battens or strips.

A. Strips of wood about 2″ × 6″ which run fore-and-aft in a ship's cargo space and bolted to the inside flange of the frame.

Q. What are gudgeons?

A. The sockets riveted to the rudder post that the pintles of the rudder are shipped into.

Q. Give a general description of various floor plates.

A. At the bow or stern the floor plates over the fore-foot or stern are increased in depth, and lose their girder-like formation found in the body of the vessel. At the bow they serve the purpose of uniting the frames on both sides together. At the extreme after end of the vessel the

frames meet a more acute angle than at the bow, and are bossed around the shaft tube. In each floor plate a limber or water-course is provided along the keel for allowing bilge-water to flow to the strum boxes. These water-courses vary in size from 2″ to 4″. All floors are fitted with lightening holes, which are to lighten the plate, and also for accessibility to the various parts of double bottoms.

Q. What is the angle of full efficiency of a rudder?

A. About 40 degrees.

Q. Describe a stern frame. Connection.

A. The after post is connected to transom floors which extend from side to side of the vessel on the forward side of the post above the counter. The lower or bottom piece extends forward enough to allow a good connection by a scarph to the keel.

Q. Describe a bar keel.

A. This keel is made from forged iron, the lengths vary from 20 to 50 feet and are united so as to form a continuous bar from stem bar to stern frame. The scarphs connecting the various lengths are identical to those connecting the stem bar and the stern frame to the keel. The lengths of the scarphs are nine times the thickness of the keel. The keel is double riveted with rivets $\frac{1}{4}$″ in diameter more than rivets required for plates the thickness of the garboard strakes.

Q. Describe a flat plate keel.

A. A flat plate keel resembles an ordinary strake of outside plating with the exception of its much greater thickness than the adjoining strakes. This is necessary because of the wear and tear to which the plate is often subject, and in conjunction with the centre thru plate which stands upon it, and is strongly attached to it, assists in giving longitudinal strength. A flat plate keel is usually about 36″ in width for ordinary vessels. The angle bars by which the connection of the centre thru plates is made are also of exceptional size and thickness. The rivets are spaced about five diameters apart. The keel plate is further assisted by garboard strakes.

Q. Describe the main keelson.

A. The keelson runs in a fore-and-aft direction over the keel. The principal parts being a deep vertical plate with two large angles on the bottom connected to the reverse frames and the lug piece connecting the frames.

On the upper edge two similar large angles with a plate known as a rider plate covering the full width of the top flanges. The large flanges are arranged vertically for the bottom bars. The butts of both centre plate and rider plate should be either strapped or over-lapped and treble riveted. The butts of the angle bars should be connected by bosom piece with at least three rivets on each side of the butts. The butts of vertical plate, rider plate and angles should be kept as clear as possible from each other.

Q. Describe a side keelson.

A. All vessels should have these to afford longitudinal strength upon the floors at the lower turn of the bilge. Usually a double angle bar riveted back to back running fore and aft the entire length of the vessel. Connection is made by short lug bars in addition to the ordinary reverse frames.

Q. Describe bilge stringers.

A. This stringer runs along the bilge giving longitudinal strength. Stringers in many respects are very similar to keelsons running fore-and-aft as far as practicable and their ends should be connected to a breast-hook (a horizontal plate binding the two sides of a vessel together). Angle lugs are required in addition to the reverse frames in order to give a good connection to the transverse framing.

Q. How are ends of plates joined in transverse joints?

A. Ends are joined by means of fitting a heel piece (a piece of iron about 3 feet long) of the same size of the frames on the opposite side of the floor and covering the butt, and in the case of the reverse bar by fitting a short covering piece on the opposite side of the floor and riveting both ends.

Q. Describe beams.

A. The beam is a steel or iron bar uniting (in a single deck ship) the uppermost extremities of the frame and preventing by its own tensile strength and rigidity the tendency of the frame heads to open wider apart from each other when the vessel is subjected to stresses, such as loading, or the pressure of the water on the immersed skin of the ship. Beams thus form the function of both struts and ties. They are securely riveted to a beam knee, which should extend three times the depth of the beam down the frame to which it is securely riveted.

Q. Describe the spacing of rivets.

A. No rivets should come nearer to the edge of any plate or bar than its own diameter. Rivets thru keelsons, bilge and side stringers, floors, frames, reverse frames are spaced about five to seven diameters from centre to centre of rivets and doubled. The butts of outside plating, deck plating, inner bottom plating and bulkheads are about four to five diameters apart and are either staggered or chain riveted and doubled, and in places treble riveted, with the exception of bulkheads which are never more than double riveted and often single chain riveted.

Q. What class of vessels are bar keels used in?

A. These are used only in single bottom vessels.

Q. What is a sole plate?

A. A plate under engine bed for it to rest on.

Q. What is a boss?

A. The boss is the central part of a propeller, which is fastened on shaft, and supports the blades.

Q. What is a head-ledge?

A. It is the framing or hatch coaming on the forward and after side of a hatch.

Q. Describe breast-hooks.

A. Triangular plates connecting the ends of stringers. All stringers, wherever practicable, should be carried all fore and aft, and united at the ends of the vessel by means of breast-hooks. In large vessels, an extra breast-hook should be fitted at the stem between each tier of beams for the further support of the shell plating.

Q. Describe a bilge keel.

A. A bilge keel is a projecting fin or some kind usually attached to the outside shell plating on the turn of the bilge, the resistance of which, as it oscillates with the rolling movements of the vessel, conduces to the desirable quality of steadiness or easiness, and reduction of the angle of inclination. It usually consists of a bulb plate 8″ to 12″ in width, riveted between double angles. It may be either riveted through the shell or connected by means of tap rivets. They should be placed so as to give the least possible resistance to propulsion, and kept as clear as possible from shell landings, tank side riveting, etc.

Q. What is a stopper?

A. As rudders are not usually allowed to turn more than an

angle of 40° or 45° on either side, it is essential to have what are called stoppers, usually upon the gudgeons, and, if necessary, upon the rudder as well.

Q. What are spectacles?

A. Special support is provided for the extreme ends of the tail shaft by means of what are commonly known as the spectacles. This is usually a steel casting in one piece, firmly bolted through the fore post of the stern frame, and securely riveted to the bossed plating of the shell.

CHAPTER III

ARITHMETIC OF NAVIGATION

The arithmetic used in navigation consists of the plain rules of arithmetic (addition, subtraction, multiplication and division). The addition, subtraction, multiplication and division of decimal fractions, and the addition, subtraction and division of degrees, minutes and seconds, and hours, minutes and seconds.

It is taken for granted that the student knows the plain rules of arithmetic.

ADDITION OF DECIMALS

In addition of decimals place the numbers that are to be added so that the decimal points will be over each other, and add as a whole number. Place the decimal point in answer under the decimal points in the line.

For example: Add 2894.965; 238.6; and 28.65.

$$\begin{array}{r} 2894.965 \\ 238.6 \\ 28.65 \\ \hline \text{(Ans.)}\quad 3162.215 \end{array}$$

SUBTRACTION OF DECIMALS

In the subtraction of decimals place the decimal point in the numbers so that they will be under each other, and the decimal point in the remainder will be under the decimal point.

For example: Subtract 2846.65 from 3897.286.

$$\begin{array}{r} 3897.286 \\ -2846.65 \\ \hline \text{(Ans.)}\quad 1050.636 \end{array}$$

MULTIPLICATION OF DECIMALS

In the multiplication of decimals multiply as in whole numbers, and count the number of decimal places there are in both numbers, which will be the number of figures counting from the right, where the decimal point goes in the product.

For example: Multiply 24.48 by 2.6.

```
  24.48
× 2.6
------
 14688
 4896
------
(Ans.) 63.648
```

DIVISION OF DECIMALS

In the division of decimals divide as whole number. If the divisor has more decimals than the dividend, add that many decimal zeros to the dividend before making the division. To place the decimal point, subtract the number of decimals in the divisor from the number of decimal places in the dividend, and point off as many decimal places in the quotient as there are in the remainder.

Example: Divide 322 by .26.

```
.26)322.000(1238.4 nearly (Ans.)
   26
  ---
   62
   52
  ---
  100
   78
  ---
  220
  208
  ---
  120
  104
  ---
   16
```

ADDITION OF DEGREES, MINUTES AND SECONDS, OR HOURS, MINUTES AND SECONDS

The degrees (or hours), minutes and seconds must be directly under their like numbers.

For example: Add 26° 47′ 36″ and 51° 27′ 42″.

26°	47′	36″	
51°	27′	42″	
78°	15′	18″	(Ans.)

Adding the seconds gives $78-60=18''$ left with 1′ to carry. Adding the minutes gives $75-60=15'$ left with 1° to carry. Adding degrees gives 78°.

Example: Add 12° 23′ 38″, 42° 37′ 15″ and 15° 46′ 39″

12°	23′	38″	
42°	37′	15″	
15°	46′	39″	
70°	47′	32″	(Ans.)

SUBTRACTION

The numbers must be directly under their like numbers.

For example: Subtract 40° 52′ 48″ from 76° 29′ 36″.

76°	29′	36″	
−40°	52′	48″	
35°	36′	48″	(Ans.)

In subtracting, if the number of seconds in the minuend is less than the number in the subtrahend, take 1′ or 60″ from the minutes and add it to the minuend. In this example 36″ is less than 48″, so borrow 1′ and make it 96″, then subtract 48″ from this, which leaves 48″. The minutes will then be 28. It is now necessary to borrow 1°, and add 60 to the minutes for the next subtraction which will make $88'-52'=36'$. The degrees are now 75, from which subtracting 40° leaves 35°.

MULTIPLICATION

Example: Multiply 13° 52′ 18″ by 4 = 55° 29′ 12″ (Ans.). Beginning with seconds

$4 \times 18 = 72 - 60 = 12''$ with $1'$ to carry
$4 \times 52 + 1 = 209' - 180' = 29'$ with $3°$ to carry
$4 \times 13° + 3° = 55°$

DIVISION

In dividing, if there is any remainder it should be changed into the next smaller unit.

Example: Divide 38° 57′ 12″ by 2.

$$\begin{array}{r} 2)38° \quad 57' \quad 12'' \\ \hline 19° \quad 28' \quad 36'' \end{array} \quad \text{(Ans.)}$$

2 into 38° = 19°
2 into 57′ = 28′ and 1′ left
12″ + 60″ = 72″ and 2 into 72″ = 36″

TO CHANGE TIME TO ARC AND THE REVERSE

To change longitude in time to longitude in degrees, minutes and seconds, and vice versa, it should be noted that:

$360° = 24\text{h}$
$15° = 1\text{h}$
$1° = 4\text{m}$
$15' = 1\text{m}$
$1' = 4\text{s}$

To change time into arc:

Multiply the hours by 60 and add the minutes.
Divide the minutes by 4, will give degrees.
If any remaining minutes add them to the seconds.
Divide the seconds by 4, will give the minutes.
If any seconds left multiply them by 60 and divide by 4, will give seconds.

Example: Change 9h 37m 14s to arc.

$$9\text{h} \times 60 + 37 = \frac{577\text{m}}{4} = 144° \text{ with } 1\text{m left}$$

$$14\text{s} + 1\text{m or } 60\text{s} = \frac{74\text{s}}{4} = 18' \text{ with } 2\text{s left}$$

$$2\text{s} \times 60 = \frac{120\text{s}}{4} = 30'' ,$$

(Ans.) 144° 18′ 30″

To change arc to time:

Multiply degrees by 4, and divide by 60, gives hours and minutes.

Multiply minutes by 4, and divide by 60, gives minutes and seconds.

Multiply seconds by 4, and divide by 60, gives seconds.

Example: Change 81° 48′ 30″ to time.

$$81^\circ \times 4 = \frac{324}{60} = 5\text{h} \quad 24\text{m}$$

$$48' \times 4 = \frac{192}{60} = \quad 3\text{m} \quad 12\text{s}$$

$$30'' \times 4 = \frac{120}{60} = \quad 2\text{s}$$

(Ans.) 5h 27m 14s

CHAPTER IV

EXPLANATION OF TABLES IN THE AMERICAN PRACTICAL NAVIGATOR (BOWDITCH)

TABLE 3

Is to find the difference of latitude and departure in miles for any course in degrees.

The degrees of the course are found at top of page from 1° to 45°, from bottom of page from 45° to 89°.

When the course is less than 45° read the table as follows:

Distance in 1st column. Diff. lat. in 2d column. Departure in 3d column.

When course is more than 45°:

Distance in 1st column. Departure in 2d column. Diff. lat. in 3d column.

For example: Course N 38° E. Distance 48 miles.

Diff. lat. will be 37.8 N. Departure 29.6 E.

Course N 52° E. Distance 48 miles.

Diff. lat. will be 29.6 N. Departure 37.8 E.

TABLE 5

Is the Meridional parts, or Increased Latitudes.

The degrees of latitude are read from top of page, minutes from side.

For example: Lat. 28° 46′ = Mer. Parts 1792.2

TABLE 7

Is to determine the distance of an object by two bearings. (See chapter on determining distance by fixed bearings.)

TABLE 42

Is to convert arc into time, and the reverse.

There are 4m of time to 1° of arc, and 4s of time to 1′ of arc, and this table is based on this principle.

For example: To turn long. 94° 32′ into time. By figures we multiply 94 by 4 and divide by 60, or $94 \times 4 = 376$ divided by 60 = 6h 16m. The same rule applies for the minutes, so $32 \times 4 = 128$ divided by 60 = 2m 8s. By adding these two together we get 6h 18m 8s longitude in time.

By using Table 7 we find that 94° = 6h 16m, and that 32′ = 2m 8s. By adding these together we get the same result as above.

The use of this table reduces the amount of figures in computing considerably, but the student should understand the principle it is based on.

To turn longitude in time into arc, we proceed in figures as follows.

Example: Turn longitude in time 6h 18m 8s into arc.

Multiply hours by 60 and add the minutes or $6h \times 60 = 360m + 18m = 378m$. Divide result by 4, or 378m divided by 4 = 94° with 2m left over. Reduce minutes left to seconds by same rule and add seconds. Or $2m \times 60 = 120s + 8s = 128s$ divided by 4 = 32′ or long. 94° 32′.

To use Table 7 proceed as follows:

Take the hour and nearest minute that can be found, which will be 6h 16m, which we find by the table equals 94°. We then have 2m 8s left over. Looking for 2m 8s we find 32′ or long. 94° 32′.

When using this table remember that degrees of arc are read as hours and minutes of time, minutes of arc as minutes and seconds of time, and seconds of arc as seconds and 1/60s of time.

TABLE 26

Is used to find the time of Moon's Meridian Passage over any Meridian.

The difference between moon's transit is found from top of page, and longitude of place at side.

The numbers taken from this table are to be added to the time of Greenwich transit in west longitude, subtracted in east longitude.

TABLE 18

Is the dip of the sea horizon. With the height of eye above sea level in feet in left-hand column the dip of the horizon will be found in right-hand column, and is always to be subtracted from observed altitude.

Example: Height of eye (or dip), 21 ft. What is correction?

(Ans.) Correction to obs. alt. −4′ 29″

TABLE 20

Is the sun's parallax in altitude. It is not necessary to use this table for the fact that it is combined with the sun's refraction in Table 20B.

TABLE 21

Is the horizontal parallax of a planet. With the Horizontal Parallax of the planet from the N. A. at top, and altitude at side, the figures obtained will be the parallax in seconds to be added to altitude.

For example: Horizontal parallax "Venus" on Feb. 1 from N. A. is 0′.09 or 5″. Altitude 37°.

Table 17 with Alt. 37° at side H. P. 5″ at top we find 4 or H. P. +4″.

TABLE 22

Is the mean refraction, to be subtracted from a star's apparent altitude.

The apparent altitude is read in first column, and the mean refraction will be found in second column.

For example: Alt. 19° 12′ = Refraction −2′ 46″.

TABLE 23

Is the correction for the sun's apparent altitude for refraction and parallax, always to be subtracted.

For example: Alt. 28° 49′ = R. & P. −1′ 38″.

TABLE 29

Is the variation in altitude for 1m from Meridian Passage, and is used for finding the latitude by ex-meridian observations of a heavenly body.

With the declination to nearest degree at top of page, and latitude to nearest degree at side, the variation in altitude for 1m will be read.

NOTE.—Always notice whether latitude and declination are same or contrary names.

For example: Lat. D. R. 28° N Decl. 18° S = Var. in alt. for 1m 2″.3.

(See ex-meridian altitudes of sun, moon or stars.)

TABLE 32

Is the logarithm of numbers from 1 to 9999.

For finding the logarithm of a number proceed as follows: 1, 2 or 3 figures in the number the logarithm will be read alongside of the number in the 0 column.

Four figures in the number, the first 3 numbers will be read on the side and the last number from top of page.

Every logarithm has an index number—i.e., the number in front of the decimal point, which is found by following rule:

Number between 0 and 10	Index number is 0
Number between 10 and 100	Index number is 1
Number between 100 and 1000	Index number is 2
Number between 1000 and 10,000	Index number is 3

For example:

Log. of 8 = 0.90309
Log. of 28 = 1.44716
Log. of 365 = 2.56229
Log. of 4888 = 3.68913

TABLE 33

Is the logarithms of the sines, cosecants, tangents, cotangents, secants and cosines.

From 0° to 45° will be found from top of page, and minutes in left-hand column, reading down.

From 45° to 90° will be found on bottom, minutes on right-hand side, reading up.

For example: Log. Sine of 18° 48′ = 9.50821
Log. Sine of 71° 12′ = 9.97619

To find the logs. to the nearest second of angle, proceed as follows:

If angle is larger than 4°, between each two columns of logs. there is a column of differences, the seconds corresponding being the left-hand column of minutes. Find the log. to the nearest minute, and then look down the left-hand column to where the number of seconds is found; then look straight across to the vertical column of differences next to that in which the log. was found for the correction. The correction is to be added if the log. is increasing, subtracted if decreasing.

If angle is smaller than 5° the difference for 1′ is given. This must be divided by 60 to give the difference for 1″. It must then be multiplied by the number of seconds to give the correction.

For example: Find log. cosine of 73° 39′ 24″.

Log. cosine 73° 39′	=	9.44948
24 in left-hand column = Diff.	−	17 decreasing cosine
Log. cosine 73° 39′ 24″ =		9.44931

Find log. sine 59° 38′ 42″

Log. sine 59° 38′	=	9.93591
42 in left-hand column = Diff.	+	5 sine increasing
Log. sine 59° 38′ 42″	=	9.93596

TABLE 34

Is the table for log. haversines and nat. haversines. The log. haversine is in light type, the nat. haversine in heavy type.

When looking for the log. haversine for L. A. T., if the sight is A. M., the hours and minutes of time are read from bottom of page, subtracting 12 from the hours, and the seconds from right-hand column, reading up the page.

For example: Feb. 9, 1925, A. M. at ship. Log. hav. as found from sum of logs. 9.38624. Required L. A. T.

Log. hav. 9.38624 = L. A. T. 9d 8h 3m 32s

If the sight is P. M. the hours and minutes will be found on top of page in light type, and the seconds will be found on left-hand side, reading down the page. It will be necessary to add 12 hours to the hours of P. M. time.

For example: Feb. 9, 1925, P. M. at ship. Log. hav. as found from sum of logs. 9.38624. Required L. A. T.

Log. hav. 9.38624 = L. A. T. 9d 15h 56m 28s.

NOTE.—The above methods may be changed in the new printing of Bowditch, but for all editions previous to 1924 the above rule will apply.

For turning longitude in time into arc proceed as follows:

In light type at top will be found longitude in time, alongside of it in heavy type longitude in degrees and

minutes. The seconds of time will be found in light type in left-hand column, and its corresponding minutes of arc in heavy type.

For example: Reduce longitude in time 3h 56m 28s to arc.

Alongside 3h 56m we find		59°	0′	0″
At 28s we find +7′	+		7′	0″
3h 56m 28s		59	7	0

To find the nat. hav. either look for the log. hav. or for the degrees, minutes or seconds given.

For example: Find the nat. hav. of log. hav. 9.38624.

Log. hav. 9.38624 = nat. hav. .24335
Nat. hav. .24335 = 59° 7′
Nat. hav. of 59° 7′ = .24335
Nat. hav. 59° 7′ 15″ = .24339

TABLE 40

Is the correction to be applied to an observed altitude of sun or star to find true altitude.

To correct the sun's observed altitude proceed as follows:

Example: Jan. 28, 1925. Obs. Alt. Sun's L. L. 28° 50′ Dip 28 ft. Required true altitude.

Obs. Alt.		28°	50′	0″	Corr. (46)	9′	11″
Corr. (46)	+		9′	28″	Table below	+	17″
True Alt.		28°	59′	28″	Total	+9′	28″

Jan. 28, 1925. Obs. Alt. *Sirius 28° 50′ Dip 28 ft. Required true altitude.

Obs. Alt.		28°	50′	0″
Corr. (46)	−		6′	57″
True Alt.		28°	43′	3″

In the correction for the sun's L. L. it is necessary to apply the correction from the table below, as by the sign given in table.

TABLE 35

Is the change in longitude due to a change of 1′ in latitude. The error in latitude found between that used at observation and the correct latitude is multiplied by the figures obtained from this table, and the result will be the error in longitude.

(See Double Chronometer Method.)

TABLE 41

Is the correction for the moon's observed altitude given in two separate tables, one for lower limb, and one for upper limb.

(See chapter on Latitude by Meridian Altitude of Moon for full explanation.)

CHAPTER V

DAY'S WORK OR SHIP'S POSITION BY DEAD RECKONING

This problem is to find the ship's position when no observations are obtainable. It is accurate as long as the proper distance on each course is allowed, and leeway, deviation, and variation are correct.

The leeway is the amount the ship is drifting to leeward from the compass course, and is by the judgment of the navigator set to so many degrees or points of the compass.

The deviation is the difference between the compass course and the magnetic course, and is explained under Deviation of the Compass.

The variation is the difference between the magnetic course and true course, and is explained under Variation of the Compass.

To convert a compass course into a true course allow easterly deviation and variation to the right of the compass course; westerly to the left, always imagining yourself standing in the center of the compass and looking toward the course you are steering.

To convert a true course into a compass course, allow east to left; west to right.

The departure course is the bearing of the point of departure by a compass. This course must be reversed (imagining the ship to have sailed from the point to the place you are at time of taking the bearing), and corrected for the deviation and variation for the ship's head, making the bearing true, and entered in the traverse table as a regular course.

The courses are then corrected for Leeway, deviation and variation, and entered in traverse table.

The current course is the amount and direction the current has set the ship for the day, and is corrected for Variation only, and entered in traverse table as a regular course.

The traverse table is drawn and the true courses and distance of each entered.

The difference of latitude and departure is found for

each course and distance, from Table 2 (Bowditch) and entered in traverse table.

The difference of latitude is the amount of latitude north or south in miles the ship has run on the course.

The departure is the amount of easting or westing in miles the ship has made on the course.

The latitude and departure columns are then added up separately, and the less subtracted from the greater.

The amount of each left will be the difference of latitude north or south, and departure east or west.

The latitude left is now put down and the difference of latitude converted into degrees, minutes and seconds, allowing 60 miles to 1° of latitude from the equator to the poles.

Applying this difference of latitude to latitude left will give the latitude arrived at.

A degree of longitude is worth 60 miles on the equator or Lat. 0° but on account of the curvature of the earth there is no longitude at the poles or Lat. 90°. It is then necessary to find the value of a degree of longitude halfway between the latitude left and latitude arrived at, we then proceed as follows:

To find Middle Latitude: Add together, Lat. left and Lat. in, and divide sum by 2. Answer will be Middle Latitude.

The longitude left is now put down and the difference of longitude is found as follows:

Enter Table 2 (Bowditch) with Middle Latitude to nearest degree as a regular course, look in the latitude column for the difference of departure, and in the distance column will be the difference of longitude in minutes.

Convert this difference of longitude in minutes into degrees, minutes and seconds by dividing by 60, and apply to longitude left. Answer will be longitude arrived at.

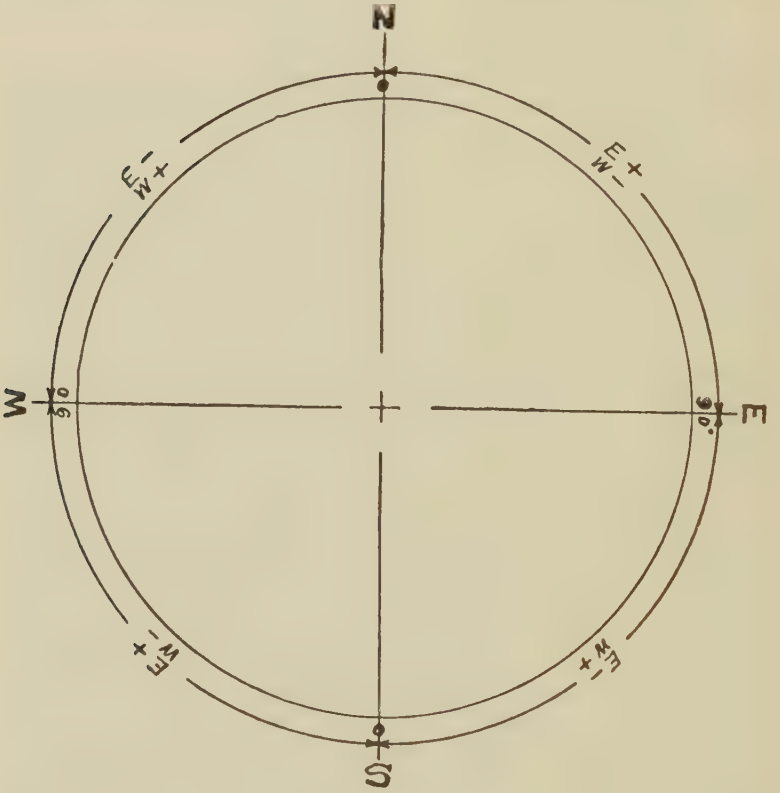
The latitude and longitude arrived at will be the position of the vessel by dead reckoning.

To find the true course and distance made in a straight line between the places, enter Table 2 (Bowditch) and compare the difference of latitude in miles with the departure in miles as close as possible.

Where these two compare will be the course and distance.

The course will be found from top of page if difference of latitude is greatest number.

From bottom of page if Departure is greatest number. In the distance column opposite to where these agree will be the distance ship has run.



DIAGRAM

For Converting Compass Courses into True Courses

Allow easterly deviation and variation to the right.
Allow westerly deviation and variation to the left.

To Convert a True Course into a Compass Course

Allow easterly deviation and variation to the left.
Allow westerly deviation and variation to the right.

To Convert a True Course into a Magnetic Course

Allow for variation only, to the left for easterly, to the right for westerly.

To Convert a Compass Course into a Magnetic Course

Allow for deviation only, to the right for easterly, to the left for westerly.

PROBLEM NO. 1

A ship takes her departure from Lat. 28° 14′ 00″ N, Long. 79° 30 W and sails the following courses:

Courses	Distance	Deviation	Variation
N 20° W	26	4° E	8° W
S 16° E	31	4° W	8° W
S 80° W	35	6° E	8° W
S 70° E	40	12° W	8° W
N 40° E	45	6° E	8° W
North	50	3° E	8° W

Required Lat. and Long. arrived at. True course and distance made?

1st Course

N 20° W
Dev. 4° E to right

N 16° W
Var. 8° W to left

N 24° W (true)

2d Course

S 16° E
Dev. 4° W to left

S 20° E
Var. 8° W to left

S 28° E (true)

3d Course

S 80° W
Dev. 6° E to right

S 86° W
Var. 8° W to left

S 78° W (true)

4th Course

S 70° E
Dev. 12° W to left

S 82° E
Var. 8° W to left

East (true)

5th Course

N 40° E
Dev. 6° E to right

N 46° E
Var. 8° W to left

N 38° E (true)

6th Course

North
Dev. 3° E to right

N 3° E
Var. 8° W to left

N 5° W (true)

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 24° W	26	23.8			10.6
S 28° E	31		27.4	14.6	
S 78° W	35		7.3		34.2
East	40			40.0	
N 38° E	45	35.5		27.7	
N 5° W	50	49.8			4.4
		109.1	34.7	82.3	49.2
		34.7		49.2	

Diff. Lat. 74.4 N Dep. 33.1 E

Latitude left 28° 14′ 00″ N
Diff. Lat. 1° 14′ 24″ N

Latitude in 29° 28′ 24″ N

2)57° 42′ 24″

Middle Lat. 28° 51′ 12″ or 29°

Longitude left 79° 30′ W
Diff. Long. 38′ E

Longitude in 78° 52′ W

True course N 24° E. Distance 81 miles.

PROBLEM NO. 2

Ship takes her departure from a point in Lat. 37° 03′ N Long. 9° 00 W bearing by compass N 48° E distance 15 miles. Ship's head S 67° W.

Courses	Distance	Wind	Leeway	Deviation	Variation
S 67° W	45	N W	6°	11° W	22° W
N 39° W	49	S W	3°	17° W	22° W
N 22° W	38	West	9°	11° W	22° W
N 56° W	31	S W	14°	20° W	22° W
S 39° W	36	S E	11°	6° W	22° W
S 84° W	41	South	6°	14° W	22° W

Current set S 65° W (Corr. Mgc.) 8 miles for day.

Required Lat. and Long. arrived at. True course and distance made?

PROBLEM NO. 2

Method of Converting Compass Courses into True Courses Before Entering in Traverse Table

No. 1

Bearing course N 48° E to be reversed and read
S 48° W
Dev. 11° W to left

S 37° W
Var. 22° W to left

S 15° W (true)

No. 2

S 67° W
6° Leeway to left

S 61° W
Dev. 11° W to left

S 50° W
Var. 22° W to left

S 28° W (true)

No. 3

N 39° W
3° Leeway to right

N 36° W
17° W Dev. to left

N 53° W
22° W Var. to left

N 75° W (true)

No. 4

N 22° W
9° Leeway to right

N 13° W
11° W Dev. to left

N 24° W
22° W Var. to left

N 46° W (true)

No. 5

N 56° W
14° Leeway to right

N 42° W
20° W Dev. to left

N 62° W
22° W Var. to left

N 84° W (true)

No. 6

S 39° W
11° Leeway to right

S 50° W
6° W Dev. to left

S 44° W
22° W Dev. to left

S 22° W (true)

No. 7

S 84° W
6° Leeway to right

W 90°
14° W Dev. to left

S 76° W
22° W Var. to left

S 54° W (true)

No. 8 Current

S 65° W set of current magnetic
22° W Variation

S 43° set of cur. true

The true courses are now entered in traverse table with their distance in the distance column, and the difference of latitude and departure found for each in Table 2.

ANSWER TO PROBLEM NO. 2

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
S 15° W	15		14.5		3.9
S 28° W	45		39.7		21.1
N 75° W	49	12.7			47.3
N 46° W	38	26.4			27.3
N 84° W	31	3.2			30.8
S 22° W	36		33.4		13.5
S 54° W	41		24.1		33.2
S 43° W	8		5.9		5.5
		42.3	117.6	Dep.	182.6W
			42.3		

Diff. Lat. 75.3 S

Lat. left 37° 03′ 00″ N
Diff. Lat. 1° 15′ 18″ S

Lat. in 35° 47′ 42″ N
Lat. left 37° 03′

2)72° 50′ 42″

Mid. Lat. 36° 25′ 21″ or 36°

Long. left 9° 00′ W
Diff. Long. 3° 46′ W

Long. in 12° 46′ W

True course S 68°W. Distance 197 miles.

PROBLEM NO. 3

A ship takes her departure from a point in Lat. 28° 16′ 15″ N Long. 93° 26′ W and sails the following courses:

Courses	Distance	Wind	Leeway	Deviation	Variation
North	50	West	4°	6° E	18° W
N 20° W	52	West	5°	8° W	18° W
West	53	North	6°	7° E	18° W
S 49° W	54	North	7°	8° W	18° W
S 79° W	55	North	7°	9° E	18° W
South	56	West	20°	7° E	18° W
S 10° E	57	West	8°	6° W	18° W

Current set East (Corr. Mgc.) 8 miles or day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 3

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 8° W	50	49.5			7.0
N 41° W	52	39.2			34.1
S 73° W	53		15.5		50.7
S 16° W	54		51.9		14.9
S 63° W	55		25.0		49.0
S 31° E	56		48.0	28.8	
S 42° E	57		42.4	38.1	
N 72° E	8	2.5		7.6	
		91.2	182.8	74.5	155.7
			91.2		74.5
		Diff. Lat.	91.6 S	Dep.	81.2W

Lat. left	28°	16′	15″ N
Diff. Lat.	1°	31′	36″ S
Lat. in	26°	44′	39″ N
Lat. left	28°	16′	15″
2)	55°	00′	54″
Mid. Lat.	27°	30′	27″ or 27°
Long. left	93°	26′ W	
Diff. Lon.	1°	31′ W	
Long. in	94°	57′ W	

True course S 42° W. Distance 123 miles.

PROBLEM NO. 4

A ship takes her departure from a point in Lat. 21° 12′ N Long. 8° 15′ E bearing by Compass N 20° W. Distance 12 miles. Ship's head S 45° W.

Courses	Distance	Wind	Leeway	Deviation	Variation
S 45° W	40	South	3°	8° E	7° W
S 80° W	41	South	8°	4° E	7° W
N 75° W	42	S W	4°	5° E	7° W
N 45° W	43	West	3°	3° W	7° W
North	44	East	2°	4° W	7° W
N 10° E	45	East	3°	5° E	7° W

Current set East (Corr. Mgc.) 12 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 4

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
S 19° E	12		11.3	3.9	
S 49° W	40		26.2		30.2
S 85° W	41		3.6		40.8
N 73° W	42	12.3			40.2
N 52° W	43	26.5			33.9
N 13° W	44	42.9			9.9
N 5° E	45	44.8		3.9	
N 83° E	12	1.5		11.9	
		128.0	41.1	19.7	155.0
		41.1			19.7
		Diff. Lat. 86.9 N		Dep. 135.3W	

Lat. left 21° 12′ 00″ N
Diff. Lat. 1° 26′ 54″ N

Lat. in 22° 38′ 54″ N
Lat. left 21° 12′

2)43° 50′ 54″

Mid. Lat. 21° 55′ 27″ or 22°

Long. left 8° 15′ E
Diff. Long. 2° 26′ W

Long. in 5° 49′ E

True course N 57° W. Distance 161 miles.

PROBLEM NO. 5

A ship takes her departure from a point in Lat. 18° 14′ 12″ S Long. 156° 12′ E bearing by compass N 89° E distance 12 miles. Ship's head North.

Courses	Distance	Wind	Leeway	Deviation	Variation
North	60	East	2°	12° W	6° E
N 20° W	61	N E	4°	8° W	6° E
N 50° W	62	North	3°	4° E	6° E
N 80° W	63	North	4°	5° E	6° E
S 80° W	64	N W	5°	6° W	6° E
S 15° W	65	West	4°	14° W	6° E

Current set S 15° E (Corr. Mgc.) 18 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 5

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
S 83° W	12		1.5		11.9
N 8° W	60	59.4			8.4
N 26° W	61	54.8			26.7
N 43° W	62	45.3			42.3
N 73° W	63	18.4			60.2
S 75° W	64		16.6		61.8
S 3° W	65		64.9		3.4
S 9° E	18		17.8	2.8	
		177.9	100.8	2.8	214.7
		100.8			2.8

Diff. Lat. 77.1 N Dep. 211.9W

Lat. left 18° 14′ 12″ S
Diff. Lat. 1° 17′ 06″ N

Lat. in 16° 57′ 06″ S
Lat. left 18° 14′ 12″

2)35° 11′ 18″

Mid. Lat. 17° 35′ 39″ or 18°

Long. left 156° 12′ E
Diff. Long. 3° 43′ W

Long. in 152° 29′ E

True course N 70° W. Distance 225 miles.

PROBLEM NO. 6

A ship takes her departure from a point in Lat. 62° 12′ S Long. 171° 12′ E bearing by compass East distance 12 miles. Ship's head S 15° W.

Courses	Distance	Wind	Leeway	Deviation	Variation
S 15° W	62	West	4°	8° W	18° E
South	64	S W	5°	9° W	18° E
West	66	North	6°	7° E	18° E
N 45° W	68	West	3°	19° W	18° E
S 59° W	70	South	6°	8° W	18° E
N 50° W	72	S W	7°	10° W	18° E

Current set S 15° E (Corr. Mgc.) 18 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 6

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 80° W	12	2.1			11.8
S 21° W	62		57.9		22.2
S 4° W	64		63.8		4.5
N 71° W	66	21.5			62.4
N 43° W	68	49.7			46.4
S 75° W	70		18.1		67.6
N 35° W	72	59.0			41.3
S 3° W	18		18.0		0.9
		132.3	157.8	Dep.	257.1W
			132.3		

Diff. Lat. 25.5 S

Lat. left	62°	12′	00″ S
Diff. Lat.		25′	30″ S
Lat. in	62°	37′	30″ S
Lat. left	62°	12′	
2)	124°	49′	30″
Mid. Lat.	62°	24′	45″ or 62°
Long. left	171°	12′	E
Diff. long.	9°	08′	W
Long. in	162°	04′	E

True course S 84° W. Distance 258 miles.

PROBLEM NO. 7

A ship takes her departure from a point in Lat. 36° 56′ N Long. 75° 51′ W bearing by compass N 67° W distance 7 miles. Ship's head S 56° E.

Courses	Distance	Wind	Leeway	Deviation	Variation
S 56° E	50	East	3°	4° W	8° E
S 23° E	40	East	2°	2° W	8° E
South	20	East	4°	12° W	8° E
East	60	North	8°	3° E	8° E
N 73° E	30	North	4°	4° W	8° E
N 51° E	40	North	3°	3° E	8° E

Current set S 46° W (Corr. Mgc.) 14 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 7

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
S 63° E	7		3.2	6.2	
S 49° E	50		32.8	37.7	
S 15° E	40		38.6	10.4	
South	20		20.0		
S 71° E	60		19.5	56.7	
N 81° E	30	4.7		29.6	
N 65° E	40	16.9		36.3	
S 54° W	14		8.2		11.3
		21.6	122.3	176.9	11.3
			21.6	11.3	
			100.7 S	165.6 Dep. E	

Lat. left 36° 56′ 00″ N
Diff. Lat. 1° 40′ 42″ S

Lat. in 35° 15′ 18″ N

2)72° 11′ 18″

Mid. Lat. 36° 05′ 39″ or 36°

Long. left 75° 51′ W
Diff. Long. 3° 25′ E

Long. in 72° 26′ W

True course S 59° E. Distance 193 miles.

PROBLEM NO. 8

A ship takes her departure from a point in Lat. 0° 21′ N Long. 178° 21′ E bearing by compass S 21° E distance 13 miles. Ship's head N 18° E.

Courses	Distance	Wind	Leeway	Deviation	Variation
N 18° E	60	East	4°	7° E	9° W
N 3° W	61	N E	5°	4° E	9° W
N 45° W	62	N E	3°	1° W	9° W
West	63	North	2°	6° E	9° W
S 50° W	64	N W	1°	2° E	9° W
South	65	West	2°	6° E	9° W

Current set S 15° E (Corr. Mgc.) 24 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 8

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 23° W	13	12.0			5.1
N 12° E	60	58.7		12.5	
N 13° W	61	59.4			13.7
N 58° W	62	32.9			52.6
S 85° W	63		5.5		62.8
S 42° W	64		47.6		42.8
S 5° E	65		64.8	5.7	
S 24° E	24		21.9	9.8	
		163.0	139.8	28.0	177.0
		139.8			28.0
		Diff. Lat. 23.2 N		Dep.	149.0W

Lat. left 0° 21′ 00″ N
Diff. Lat. 23′ 12″ N

Lat. in 0° 44′ 12″ N

2)1° 05′ 12″

Mid. Lat. 32′ 36″ or 1°

Long. left 178° 21′ E
Diff. Long. 2° 29′ W

Long. in 175° 52′ E

True course N 81° W. Distance 151 miles.

PROBLEM NO. 9

A ship takes her departure from a point in Lat. 3° 10′ 12″ S Long. 0° 15′ W bearing by compass N 10° W distance 14 miles. Ship's head S 15° W.

Courses	Distance	Wind	Leeway	Deviation	Variation
S 15° W	40	S E	4°	3° W	40° E
S 15° E	41	East	5°	8° W	40° E
East	42	South	6°	1° E	40° E
N 70° E	43	South	4°	4° W	40° E
N 45° E	44	North	2°	1° E	40° E
N 15° E	45	East	1°	2° E	40° E

Current set N 16° W (Corr. Mgc.) 18 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 9

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
S 27° W	14		12.5		6.4
S 56° W	40		22.4		33.2
S 22° W	41		38.0		15.4
S 55° E	42		24.1	34.4	
S 78° E	43		8.9	42.1	
N 88° E	44	1.5		44.0	
N 56° E	45	25.2		37.3	
N 24° E	18	16.4		7.3	
		43.1	105.9	165.1	55.0
			43.1	55.0	

Diff. Lat. 62.8 S 110.1 Dep. E

Lat. left	3°	10′	12″ S
Diff. Lat.	1°	02′	48″ S
Lat. in	4°	13′	00″ S
	2)7°	23′	12″
Mid. Lat.	3°	41′	36″ or 4°
Long. left		0°	15′ W
Diff. Long.		1°	50′ E
Long. in		1°	35′ E

True course S 60° E. Distance 127 miles.

PROBLEM NO. 10

A ship takes her departure from a point in Lat. 67° 15′ 08″ N Long. 112° 12′ W bearing by compass S 80° W distance 20 miles. Ship's head North.

Courses	Distance	Wind	Leeway	Deviation	Variation
North	50	East	3°	4° E	21° W
N 40° W	51	N E	2°	9° E	21° W
N 15° W	52	N E	3°	3° E	21° W
West	53	North	2°	26° E	21° W
N 70° W	54	North	1°	2° E	21° W
S 89° W	55	South	3°	4° E	21° W

Current set S 22° E (Corr. Mgc.) 14 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 10

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 63° E	20	9.1		17.8	
N 20° W	50	47.0			17.1
N 54° W	51	30.0			41.3
N 36° W	52	42.1			30.6
N 87° W	53	2.8			52.9
West	54				54.0
S 75° W	55		14.2		53.1
S 43° E	14		10.2	9.5	
		131.0	24.4	27.3	249.0
		24.4			27.3
Diff. Lat.		106.6 N		Dep.	221.7W

Lat. left 67° 15′ 08″ N
Diff. Lat. 1° 46′ 36″ N

Lat. in 69° 01′ 44″ N

2)136° 16′ 52″

Mid. Lat. 68° 08′ 26″ or 68°
Long. left 112° 12′ W
Diff. Long. 9° 52′ W

Long. in 122° 04′ W

True course N 64° W. Distance 246 miles.

PROBLEM NO. 11

A ship takes her departure from a point in Lat. 0° 00′ Long. 0° 00′ bearing by compass South distance 18 miles Ship's head East.

Courses	Distance	Wind	Leeway	Deviation	Variation
East	70	S E	2°	12° E	18° W
S 45° E	71	South	8°	5° E	18° W
S 15° E	72	East	3°	25° E	18° W
South	73	East	4°	8° E	18° W
S 10° W	74	East	2°	4° E	18° W
S 45° W	75	S E	1°	6° E	18° W

Current set N 8° W (Corr. Mgc.) 19 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 11

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 6° W	18	17.9			1.6
N 82° E	70	9.7		69.3	
S 66° E	71		28.9	64.9	
S 5° E	72		71.7	6.3	
S 6° E	73		72.6	7.6	
S 2° E	74		74.0	2.6	
S 34° W	75		62.2		41.9
N 26° W	19	17.1			8.3
		44.7	309.4	150.7	52.1
			44.7	52.1	
		Diff. Lat.	264.7 S	98.6 Dep. E	

Lat. left 0° 00′ 00″
Diff. Lat. 4° 24′ 42″ S

Lat. in 2)4° 24′ 42″ S

Mid. Lat. 2° 12′ 21″ or 2°
Long. left 0° 00′ 00″
Diff. Long. 1° 38′ 45″ E

Long. in 1° 38′ 45″ E

True course S 20° E. Distance 281 miles.

PROBLEM NO. 12

A ship takes her departure from a point in Lat. 51° 37′ N Long. 8° 32′ W bearing by compass N 45° W distance 12 miles. Ship's head S 17° W.

Courses	Distance	Wind	Leeway	Deviation	Variation
S 17° W	26	West	3°	5° E	24° W
S 53° W	30	N W	3°	9° W	24° W
S 67° W	50	N W	6°	12° W	24° W
N 3° W	38	N W	9°	4° W	24° W
S 51° E	32	S W	0°	11° E	24° W

Current set N 79° W (Corr. Mgc.) 14 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 12

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
S 64° E	12		5.3	10.8	
S 5° E	26		25.9	2.3	
S 17° W	30		28.7		8.8
S 25° W	50		45.3		21.1
N 22° W	38	35.2			14.2
S 64° E	32		14.0	28.8	
S 77° W	14		3.1		13.6
		35.2	122.3	41.9	57.7
			35.2		41.9
		Diff. Lat.	87.1 S	Dep.	15.8W

Lat. left 51° 37′ 00″ N
Diff. Lat. 1° 27′ 06″ S

Lat. in 50° 09′ 54″ N

2)101° 46′ 54″

Mid. Lat. 50° 53′ 27″ or 51°

Long. left 8° 32′ W
Diff. Long. 25′ W

Long. in 8° 57′ W

True course S 10° W. Distance 89 miles.

PROBLEM NO. 13

A ship takes her departure from a point in Lat. 62° 11′ N Long. 5° 08′ E bearing by compass S 28° W distance 10 miles. Ship's head N 22° W.

Courses	Distance	Wind	Leeway	Deviation	Variation
N 22° W	39	N E	6°	7° W	20° W
N 68° W	36	North	8°	18° W	20° W
S 28° W	39	S E	3°	9° W	20° W
S 11° E	40	East	0°	3° E	20° W
S 6° E	35	S W	11°	2° E	20° W
N 23° E	31	N W	14°	6° E	20° W

Current set S 56° W (Corr. Mgc.) 36 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 13

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 1° E	10	10.0		0.2	
N 55° W	39	22.4			31.9
S 66° W	36		14.6		32.9
S 2° W	39		39.0		1.4
S 28° E	40		35.3	18.8	
S 35° E	35		28.7	20.1	
N 23° E	31	28.5		12.1	
S 36° W	36		29.1		21.2
		60.9	146.7	51.2	87.4
			60.9		51.2
		Diff. Lat.	85.8 S	Dep.	36.2W

Lat. left 62° 11′ 00″ N
Diff. Lat. 1° 25′ 48″ S

Lat. in 60° 45′ 12″ N
2)122° 56′ 12″

Mid. Lat. 61° 28′ 06″ or 61°

Long. left 5° 08′ E
Diff. Long. 1° 15′ W

Long. in 3° 53′ E

True course S 23° W. Distance 93 miles.

PROBLEM NO. 14

A ship takes her departure from a point in Lat. 47° 34′ N Long. 52° 40′ W bearing by compass N 70° W distance 17 miles. Ship's head N 84° E.

Course	Distance	Wind	Leeway	Deviation	Variation
N 84° E	20	S E	14°	9° E	31° W
N 20° E	33	East	6°	11° E	31° W
S 42° E	35	N E	3°	4° E	31° W
N 70° W	35	S W	5°	6° W	31° W
N 53° E	37	N W	3°	4° E	31° W
S 64° E	28	N E	5°	3° W	31° W

Current set N 73° E (Corr. Mgc.) 17 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 14

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 88° E	17	0.6		17.0	
N 48° E	20	13.4		14.9	
N 6° W	33	32.8			3.4
S 66° E	35		14.2	32.0	
S 78° W	35		7.3		34.2
N 29° E	37	32.4		17.9	
N 87° E	28	1.5		28.0	
N 42° E	17	12.6		11.4	
		93.3	21.5	121.2	37.6
		21.5		37.6	

Diff. Lat. 71.8 N Dep. 83.6 E

Lat. left 47° 34′ 00″ N
Diff. Lat. 1° 11′ 48″ N

Lat. in 48° 45′ 48″ N

2)96° 19′ 48″

Mid. Lat. 48° 09′ 54″ or 48°

Long. left 52° 40′ W
Diff. Long. 2° 05′ E

Long. in 50° 35′ W

True course N 49° E. Distance 111 miles.

PROBLEM NO. 15

A ship takes her departure from a point in Lat. 38° 43′ S Long. 77° 35′ E bearing by compass S 28° E distance 16 miles. Ship's head N 56° W.

Course	Distance	Wind	Leeway	Deviation	Variation
N 56° W	35	North	11°	16° W	25° W
S 34° E	40	S W	3°	11° E	25° W
S 6° W	41	S E	0°	2° W	25° W
N 87° W	37	North	6°	26° W	25° W
N 28° E	34	N W	20°	8° E	25° W
S 11° E	37	East	8°	3° E	25° W

Current set S 56° E (Corr. Mgc.) 39 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 15

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 69° W	16	5.7			14.9
S 72° W	35		10.8		33.3
S 51° E	40		25.2	31.1	
S 21° E	41		38.3	14.7	
S 36° W	37		29.9		21.7
N 31° E	34	29.1		17.5	
S 25° E	37		33.5	15.6	
S 81° E	39		6.1	38.5	
		34.8	143.8	117.4	69.9
			34.8	69.9	

Diff. Lat. 109.0 S 47.5 Dep. E

Lat. left 38° 43′ 00″ S
Diff. Lat. 1° 49′ 00″ S

Lat. in 40° 32′ 00″ S

2)79° 15′ 00″

Mid. Lat. 39° 37′ 30″ or 40°

Long. left 77° 35′ E
Diff. Long. 1° 02′ E

Long. in 78° 37′ E

True course S 23° E. Distance 119 miles.

PROBLEM NO. 16

A ship takes her departure from a point in Lat. 61° 19′ N Long. 179° 19′ E bearing by compass N 56° W distance 18 miles. Ship's head N 23° E.

Courses	Distance	Wind	Leeway	Deviation	Variation
N 23° E	34	N W	11°	6° E	20° E
N 56° E	40	North	3°	16° E	20° E
N 86° E	30	South	14°	21° E	20° E
S 23° W	26	S E	28°	7° W	20° E
N 73° W	30	North	20°	19° W	20° E
S 23° E	36	S W	8°	7° E	20° E

Current set S 56° E (Corr. Mgc.) 38 miles for day.

Required latitude and longitude arrived at. True course and distance?

ANSWER TO PROBLEM NO. 16

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
S 30° E	18		15.6	9.0	
N 60° E	34	17.0		29.4	
S 85° E	40		3.5	39.8	
S 67° E	30		11.7	27.6	
S 64° W	26		11.4		23.4
S 88° W	30		1.0		30.0
S 4° E	36		35.9	2.5	
S 36° E	38		30.7	22.3	
		17.0	109.8	130.6	53.4
			17.0	53.4	
		Diff. Lat.	92.8 S	77.2 Dep. E	

Lat. left 61° 19′ 00″ N
Diff. Lat. 1° 32′ 48″ S

Lat. in 59° 46′ 12″ N

2)121° 05′ 12″

Mid. Lat. 60° 32′ 36″ or 61°

Long. left 179° 19′ E
Diff. Long. 2° 39′ E

Long. in 178° 02′ W

True course S 40° E. Distance 121 miles.

PROBLEM NO. 17

A ship takes her departure from a point in Lat. 40° 19′ S Long. 9° 44′ W bearing by compass East distance 20 miles. Ship's head N 39° W.

Courses	Distance	Wind	Leeway	Deviation	Variation
N 39° W	22	S W	3°	3° E	20° W
N 23° W	23	West	3°	8° E	20° W
N 23° E	18	N W	6°	20° E	20° W
S 48° E	19	N W	0°	6° W	20° W
S 34° E	10	S W	0°	9° W	20° W
N 3° W	42	West	3°	14° E	20° W

Current set N 73° W (Corr. Mgc.) 36 miles for day.

Required latitude and longitude arrived at. True course and distance?

ANSWER TO PROBLEM NO. 17

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
S 73° W	20		5.8		19.1
N 53° W	22	13.2			17.6
N 32° W	23	19.5			12.2
N 29° E	18	15.7		8.7	
S 74° E	19		5.2	18.3	
S 63° E	10		4.5	8.9	
N 6° W	42	41.8			4.4
S 87° W	36		1.9		36.0
		90.2	17.4	35.9	89.3
		17.4			35.9

Diff. Lat. 72.8 N Dep. 53.4W

Lat. left 40° 19′ 00″ S
Diff. Lat. 1° 12′ 48″ N

Lat. in 39° 06′ 12″ S

2)79° 25′ 12″

Mid. Lat. 39° 42′ 36″ or 40°

Long. left 9° 44′ W
Diff. Long. 1° 10′ W

Long. in 10° 54′ W

True course N 36° W. Distance 90 miles.

PROBLEM NO. 18

A ship takes her departure from a point in Lat. 49° 42′ S Long. 178° 42′ E and sails the following courses:

Courses	Distance	Wind	Leeway	Deviation	Variation
N 42° E	35	S E	5°	21° E	14° E
N 73° E	36	North	3°	15° E	14° E
S 48° W	37	S E	3°	15° W	14° E
S 17° E	26	East	9°	13° W	14° E
N 8° E	33	East	8°	18° E	14° E
N 14° W	38	N E	3°	12° E	14° E

Current set N 56° E (Corr. Mgc.) 28 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 18

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 72° E	35	10.8		33.3	
S 75° E	36		9.3	34.8	
S 50° W	37		23.8		28.3
S 7° E	26		25.8	3.2	
N 32° E	33	28.0		17.5	
N 9° E	38	37.5		5.9	
N 70° E	28	9.6		26.3	
		85.9	58.9	121.0	28.3
		58.9		28.3	
		Diff. Lat. 27.0 N		Dep. 92.7 E	

Lat. left 49° 42′ 00″ S
Diff. Lat. 27′ 00″ N

Lat. in 49° 15′ 00″ S

2)98° 57′ 00″

Mid. Lat. 49° 28′ 30″ or 49°

Long. left 178° 42′ E
Diff. Long. 2° 21′ E

Long. in 178° 57′ W

True course N 73° E. Distance 96 miles.

PROBLEM NO. 19

A ship takes her departure from a point in Lat. 28° 14′ S Long. 102° 16′ E bearing by compass S 68° E distance 14 miles. Ship's head North.

Courses	Distance	Wind	Leeway	Deviation	Variation
North	60	West	4°	7° W	9° E
N 28° W	61	S W	5°	3° E	9° E
N 28° E	62	East	3°	12° E	9° E
S 87° E	63	North	2°	4° W	9° E
S 15° E	64	S W	4°	14° W	9° E
East	65	North	3°	8° W	9° E

Current set S 23° W (Corr. Mgc.) 19 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 19

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 66° W	14	5.7			12.8
N 6° E	60	59.7		6.3	
N 11° W	61	59.9			11.6
N 46° E	62	43.1		44.6	
S 80° E	63		10.9	62.0	
S 24° E	64		58.5	26.0	
S 86° E	65		4.5	64.8	
S 32° W	19		16.1		10.1
		168.4	90.0	203.7	34.5
		90.0		34.5	

Diff. Lat. 78.4 N Dep. 169.2 E

Lat. left	28°	14′	00″ S
Diff. Lat.	1°	18′	24″ N
Lat. in	26°	55′	36″ S
	2)55°	09′	36″
Mid. Lat.	27°	34′	48″ or 28°
Long. left	102°	16′	E
Diff. Long.	3°	12′	E
Long. in	105°	28′	E

True course N 65° E. Distance 187 miles.

PROBLEM NO. 20

A ship takes her departure from a point in Lat. 24° 16′ N Long. 37° 18′ W bearing by compass East distance 9 miles. Ship's head South.

Courses	Distance	Wind	Leeway	Deviation	Variation
South	70	East	4°	5° W	10° E
S 45° W	71	N W	5°	3° W	10° E
West	72	North	4°	9° E	10° E
N 80° W	73	South	4°	4° W	10° E
S 15° W	74	West	2°	3° W	10° E
N 45° W	75	N E	3°	8° W	10° E

Current set East (Corr. Mgc.) 17 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 20

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
N 85° W	9	0.8			9.0
S 9° W	70		69.1		11.0
S 47° W	71		48.4		51.9
N 75° W	72	18.6			69.5
N 70° W	73	25.0			68.6
S 20° W	74		69.5		25.3
N 46° W	75	52.1			54.0
S 80° E	17		3.0	16.7	
		96.5	190.0	16.7	289.3
			96.5		16.7
		Diff. Lat.	93.5 S	Dep.	272.6W

Lat. left 24° 16′ 00″ N
Diff. Lat. 1° 33′ 30″ S

Lat. in 22° 42′ 30″ N

2)46° 58′ 30″

Mid. Lat. 23° 29′ 15″ or 23°

Long. left 37° 18′ W
Diff. Long. 4° 56′ W

Long. in 42° 14′ W

True course S 71° W. Distance 288 miles.

PROBLEM NO. 21

I steered S 18° W by Compass, Error 18° E, Var. 7° E, 16 miles, N 18° W Magnetic, Error 18° E, Var. 7° E, 16 miles.

How would I have to steer to get back to where I started from, and if Cape Flyaway (Lat. 43° 17′ N Long. 73° 18′ E) bore North (True) 21 miles, what would be my position?

Corrected Courses	Dist.	N	S	E	W
S 36° W	16		12.9		9.4
N 11° W	16	15.7			3.1
		15.7	12.9	Dep.	12.5W
		12.9			
D. Lat.		2.8 N			

Course to steer to get back to point of Departure S 78° E 13 miles.

Cape Flyaway Lat.	43°	17′ N	Long.	73°	18′ E
Difference Lat.		21′ S			
Ship's Position Lat.	42°	56′ N	Long.	73°	18′ E

PROBLEM NO. 22

At sea in Lat. 26° 12′ N Long. 88° 13′ W. Received wireless that South Pass Light-Vessel had been adrift 47 hours. Current setting E. S. E. (Mgc.) 3 miles per hour. Now at anchor. Please find Light-Vessel and tow her back to her position Lat. 28° 59′ N Long. 89° 07′ W, Var. 5° E.

Find true course and distance to Light-Vessel and course and distance back to her position.

Corrected Courses	Dist.	N	S	E	W
S 62° E	141		66.2	124.5	

Position of Light-Vessel Lat.	28°	59′ N
Diff. Lat.	1°	06′ S
Present Position Light-Vessel	27°	53′ N
Ship's Position Lat.	26°	12′ N
Diff. Lat.	1°	41′ N

Long. of Light-Vessel	89° 07′ W
Diff. Long.	2° 21′ E
Present Long. of Light-Vessel	86° 46′ W
Ship's Position Long.	88° 13′ W
Diff. Long.	1° 27′ E
Diff. Lat. 101 N	Dep. 77.5 E

Course and distance to Light-Vessel N 38° E 127 miles.

Course and distance back to Light-Vessel's Station N 62° W 141 miles.

PROBLEM NO. 23

A ship sailed from Point Neverbudge, Lat. 41° 00′ S Long. 86° 15′ E, the following courses:

South true 14 miles.

South by Compass, Error 6° E, Var. 6° W, 14 miles.

East by Compass, Dev. 4° E, Var. 6° W, 24 miles.

West by Compass, Dev. 6° E, Var. 6° W, 24 miles.

North by Compass, Dev. 16° E, Var. 6° W, 28 miles.

Find course and distance made good and latitude and longitude arrived at.

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Difference Departure East	Difference Departure West
South	14		14.0		
S 6° W	14		13.9		1.5
N 88° E	24	0.8		24.0	
West	24				24.0
N 10° E	28	27.6		4.9	
		28.4	27.9	28.9	25.5
		27.9		25.5	
	Diff. Lat.	.5 N		Dep. 3.4 E	

Lat. left	41°	00′	00″ S	Long. left	86°	15′	00″ E
Diff. Lat.			30″ N	Diff. Long.		4′	30″ E
Lat. Ar. at	40°	59′	30″ S	Long. Ar. at	86°	19′	30″ E

Mid. Lat. (41°)

Course N 81° E. Distance 3 miles.

PROBLEM NO. 24

A ship takes her departure from a point in Lat. 51° 14′ N Long. 139° 26′ W bearing by compass 316° distance 17 miles. Ship's head 48°, and sails the following courses.

Courses	Distance	Wind	Leeway	Deviation	Variation
48°	62	0°	4°	3° E	17° W
86°	61	0°	3°	1° E	17° W
120°	60	43°	4°	0°	17° W
162°	58	90°	3°	1° W	17° W
180°	59	90°	2°	2° W	17° W
194°	60	100°	3°	3° W	17° W

Current set 258° (Corr. Mgc.) 26 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 24

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
122°	17		9.0	14.4	
38°	62	48.9		38.2	
73°	61	17.8		58.3	
107°	60		17.5	57.4	
147°	58		48.6	31.6	
163°	59		56.4	17.2	
177°	60		59.9	3.1	
241°	26		12.6		22.7
		66.7	204.0	220.2	22.7
			66.7	22.7	

D. Lat. 137.3 S 197.5 Dep. E

Lat. left	51°	14′	00″	N
D. Lat.	2°	17′	18″	S
Lat. in	48°	56′	42″	N
	2)100°	10′	42″	
Mid. Lat.	50°	5′	21″ or 50°	
Long. left	139°	26′	00″	W
D. Long.	5°	7′	15″	E
Long. in	134°	18′	45″	W

True course 125°. Distance 241 miles.

PROBLEM NO. 25

A ship takes her departure from a point in Lat. 31° 25′ S Long. 152° 57′ E bearing by compass 270° distance 15 miles. Ship's head 337°, and steers the following courses.

Courses	Distance	Wind	Leeway	Deviation	Variation
337°	23	270°	11°	5° W	11° E
11°	25	330°	14°	2° E	11° E
0°	24	317°	14°	0°	11° E
343°	26	276°	17°	4° W	11° E
0°	33	276°	0°	0°	11° E
23°	26	276°	0°	3° E	11° E

Current set 67° (Corr. Mgc.) 15 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 25

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
96°	15		1.6	14.9	
354°	23	22.9			2.4
38°	25	19.7		15.4	
25°	24	21.8		10.1	
7°	26	25.8		3.2	
11°	33	32.4		6.3	
37°	26	20.8		15.6	
78°	15	3.1		14.7	
		146.5	1.6	80.2	2.4
		1.6		2.4	

Diff. Lat. 144.9 N Dep. 77.8 E

Lat. left	31°	25′	00″ S
Diff. Lat.	2°	24′	54″ N
Lat. in	29°	0′	6″ S
	2)60°	25′	6″
Mid. Lat.	30°	12′	33″ or 30°
Long. left	152°	57′	E
Diff. Long.	1°	30′	E
Long. in	154°	27′	E

True course 28°. Distance 164 miles.

PROBLEM NO. 26

A ship takes her departure from a point in Lat. 51° 48′ N Long. 178° 24′ W bearing by compass 113° distance 20 miles. Ship's head 234°, and steers the following courses.

Courses	Distance	Wind	Leeway	Deviation	Variation
234°	57	169°	20°	7° W	20° E
197°	58	264°	17°	2° W	20° E
157°	59	90°	17°	3° E	20° E
293°	56	225°	19°	10° W	20° E
315°	61	0°	17°	10° W	20° E
0°	57	63°	12°	7° W	20° E

Current set 90° (Corr. Mgc.) 36 miles for day.

Required latitude and longitude arrived at. True course and distance made?

ANSWER TO PROBLEM NO. 26

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
306°	20	11.8			16.2
267°	57		3.0		56.9
198°	58		55.2		17.9
197°	59		56.4		17.2
322° +	56	44.1			34.5
308°	61	37.6			48.1
1°	57	57.0		1.0	
110°	36		12.3	33.8	
		150.5	126.9	34.8	190.8
		126.9			34.8
Diff. Lat.		23.6 N		Dep.	156.0W

Lat. left	51°	48′	00″ N
Diff. Lat.		23′	36″ N
Lat. in	52°	11′	36″ N
2)103°	59′	36″	
Mid. Lat.	51°	59′	48″ or 52°
Long. left	178°	24′	00″ W
Diff. Long.	4°	13′	15″ W
	182°	37′	15″ W
	360°		
Long. in	177°	22′	45″ E

True course 279°. Distance 158 miles.

PROBLEM NO. 27

DAY'S WORK

EXAMPLE:

A point in Lat. 54° 28′ S Long. 18° 14′ E bearing NW¼N. Distance 8 miles. Ship's head SW×W½W, and steers the following courses. Pitch of wheel 23.5 ft.

Courses	Wind	Leeway	Dev.	Var.	Rev.	Hours	Slip
S W×W½W	N W	¼ pt.	6° E	11° W	63.4 69.6	3	−4%
S¼W	W	¼ pt.	4° E	11° W	68.2 67.6	4	+ 4%
S S E	S W	¼ pt.	2° E	11° W	63.2 60.4	4.5	+28%
E S E	S S W	¼ pt.	0	11° W	59.3 57.7	4.5	+32%
East	S	¼ pt.	1° W	11° W	64.9 67.7	6	+18%
E N E	S E	¼ pt.	3° W	11° W	68.6 69.4	2	−18%

A current set S E (Mgc.) for 24 hours at rate of 1¼ miles per hour.

Required latitude and longitude arrived at, and true course and distance made good.

ANSWER: Correcting courses.

No. 1		No. 2		No. 3	
S E ¼ S =	S 37° E	S W×W ½ W		S ¼ W	
Dev.	6° E	¼ pt. leeway		¼ pt. leeway	
	S 31° E	S W×W ½ W =	S 59° W	South =	0°
Var.	11° W	Dev.	6° E	Dev.	4° E
True	S 42° E		S 65° W		S 4° W
		Var.	11° W	Var.	11° W
		True	S 54° W	True	S 7° E

No. 4

S S E
½ pt. leeway

S S E ½ E = S 28° E
Dev. 2° E

S 26° E
Var. 11° W

True S 37° E

No. 5

E S E
½ pt. leeway

E × S ½ S = S 73° E
Var. 11° W

True S 84° E

No. 6

East
¼ pt. leeway

E ¼ N = N 87° E
Dev. 1° W

N 86° E
Var. 11° W

True N 75° E

No. 7

E N E
½ pt. leeway

N E × E ½ E = N 65° E
Dev. 3° W

N 62° E
Var. 11° W

True N 51° E

No. 8

S E = S 45° E
Var. 11° W

True S 56° E

DETERMINING DISTANCE ON EACH COURSE

RULE:

1. Find the mean revolutions on each course per minute, and multiply by 60 minutes to find the revolutions per hour.

2. Multiply the revolutions per hour by the pitch of wheel, and divide the product by 6080. The result will be speed of ship per hour by wheel.

3. Multiply the speed by wheel by the number of hours run, and that product by the percentage of slip. The result will be the distance run.

4. To multiply by slip: When it is positive or +, subtract the percentage from 100, and multiply by difference. When it is negative or −, add the percentage to 100, and multiply by sum.

1st Distance
Departure Course
8 miles

2d Distance
63.4 Rev.
69.6 Rev.
2)133.0
66.5 Mean Rev.
×60
3990 Mean Rev. per hour
×23.5 Pitch of wheel
93765 feet per hour
6080 feet = 15.42 knots per hour

15.42×3 hours = 46.26
46.26×1.04 = 48.1
Distance in 3 hours

3d Distance
Mean Rev. 67.9×60 = 4074
$4074 \times 23.5 = \frac{95739}{6080} = 15.75$
15.75×4×.96 = 60.48 Dist.

4th Distance
Mean Rev. 61.8×60 = 3708
$3708 \times 23.5 = \frac{87138}{6080} = 14.33$
14.33×4.5×.72 = 46.43 Dist.

5th Distance
Mean Rev. 58.5×60 = 3510
$3510 \times 23.5 = \frac{82485}{6080} = 13.57$
13.57×4.5×.68 = 41.6 Dist.

6th Distance
Mean Rev. 66.3×60 = 3978
$3978 \times 23.5 = \frac{93483}{6080} = 15.37$
15.37×6×.82 = 75.6 Dist.

7th Distance
Mean Rev. 69×60 = 4140
$4140 \times 23.5 = \frac{97290}{6080} = 16$
16×2×1.18 = 37.76 Dist.

8th Distance
Current course
24 hours × 1⅛ = 27 miles Dist.

Corrected Courses	Distance	Difference Lat. North	Difference Lat. South	Departure East	Departure West
S 42° E	8		5.9	5.4	
S 54° W	48.1		28.2		38.8
S 7° E	60.5		60.0	7.3	
S 37° E	46.4		37.0	28.0	
S 84° E	41.6		4.4	41.4	
N 75° E	75.6	19.6		73.0	
N 51° E	37.7	23.7		29.2	
S 56° E	27.0		15.1	22.4	
		43.3	150.6	206.7	38.8
			−43.3	−38.8	
			D. Lat. 107.3 S	167.9 E Dep.	

Lat. left 54° 28′ 00″ S
D. Lat. 1 47 18 S
Lat. In. 56 15 18 S
Mid. Lat. 55°.

Long. left 18° 14′ 00″ E
D. Long. 4 52 40 E
Long. In. 23 6 40 E
True course S 57° E. Distance 200 miles.

CHAPTER VI

DISTANCE OFF FIXED POINT BY BEARINGS

There are several methods for determining the distance of a vessel off a fixed point, but the methods most generally used by navigators are by "Two Bearings."

In the solution of these methods it must be understood that the course of the vessel is not to be altered between the time of first and second bearing, and the speed of the vessel over the ground must be accurately known.

FIRST METHOD

Two Bearings of a Known Object

This method is frequently employed, and is useful in determining the distance off at time of second bearing, and also when abeam of point.

RULE: To find distance off at time of second bearing.

1. Take a careful bearing when the fixed point is more than 20° off the bow, and note the time or log.
2. After running a convenient distance take a second bearing, and note the time or log.
3. Determine the distance the ship has run between the two bearings.
4. Find the difference between course of ship and first bearing, in points or degrees.
5. Find the difference between course of ship and second bearing, in points or degrees.
6. If difference is found in points, enter Table 5A (Bowditch) in the first column, and take out the figures under the proper head.
7. Multiply these figures by the distance run between bearings, and the result will be the distance off the fixed object or point at the time of second bearing.
8. If the difference is found in degrees, enter Table 5B (Bowditch) in the first column, and the result will be as above.

EXAMPLE 1

A vessel is steering N×E ¾ E and takes a bearing of a light N E ½ E, after running 6.7 miles she takes another S E×E. Required the distance off the light at time of second bearing?

Difference between course and first bearing = 2¾ points
Difference between course and second bearing = 9¼ points
Figures from Table 5A, first column = 0.54
6.7 miles × 0.54 = 3.6 miles, distance off at second bearing.

EXAMPLE 2

A vessel is steering 310° and takes a bearing of a light 287°, after running 9.3 miles she takes another bearing 184°. Required the distance off the light at time of second bearing?

Difference between course and first bearing = 23°
Difference between course and second bearing = 126°
Figures from Table 5B, first column = 0.405
9.3 miles × 0.405 = 3.8 miles, distance off at second bearing.

RULE: To find distance off at time object is abeam.

1–5. Same as above.

6. If difference is found in points, enter Table 5A (Bowditch), in the second column, and take out the figures under the proper head.

7. Multiply these figures by the distance run between bearings, and the result will be the distance off the fixed object or point when abeam.

8. If the difference is found in degrees, enter Table 5B (Bowditch), in the second column, and the result will be as above.

EXAMPLE 1

A vessel is steering N×E ¾ E and takes a bearing of a light N E ½ E, after running 6.7 miles she takes another bearing S E×E. Required the distance off the light when abeam.

Difference between course and first bearing = 2¾ points
Difference between course and second bearing = 9¼ points
Figures from Table 5A, second column = 0.52
6.7 miles × 0.52 = 3.5 miles, distance off when abeam.

EXAMPLE 2

A vessel is steering 310° and takes a bearing of a light 287°, after running 9.3 miles she takes another bearing 184°. Required the distance off the light when abeam?
Difference between course and first bearing = 23°
Difference between course and second bearing = 126°
Figures from Table 5B, second column = 0.325
9.3 miles × 0.325 = 3 miles, distance off when abeam.

SECOND METHOD

Distance Off a Fixed Object when Abeam by Two Bearings

In the following table the distance at which the object will be passed abeam will equal the run between bearings.

RULE:

1. Take the first bearing as per table, and note the time and log.
2. Take the second bearing as per table, and note the time and log.
3. The distance run between the two bearings will be the distance off the object when it is abeam.

TABLE

Bearings from Ahead		Bearings from Ahead	
First	Second	First	Second
22°	34°	32°	59°
25°	41°	40°	79°
27°	46°	44°	88°
29°	51°	45°	90°

Example: A bearing is taken of a fixed object 29° off the bow, log read 13, another bearing is taken at 51°, patent log read 20. Required distance off object when abeam.

20 − 13 = 7 miles, distance off when abeam

THIRD METHOD

The Seven-tenths Rule

If bearings of the fixed object be taken at 2 and 4 points on the bow (22½° and 45°), seven-tenths (0.7) of the run between bearings will be the distance at which point will be passed abeam.

Example: A bearing is taken at 2 points on the bow,

log read 14; another bearing is taken at 4 points on the bow, log read 22. Required distance off when abeam.

$22 - 14 = 8$ miles run between bearings
$8 \times 0.7 = 5.6$ miles off when abeam

FOURTH METHOD

Bow and Beam (or Four-point) Bearings

When a lighthouse or any fixed object bears 4 points (or 45°) on the bow, the distance run from the time of taking the 4-point bearing until the fixed object is abeam (or bears 90° on the bow) will be the distance off the fixed object when abeam, if the vessel has steered the same course in the interval.

RULE:

1. Take a bearing when the object is 4 points on the bow. Either read patent log or note time by clock.
2. When fixed object is abeam, either read log or note time by clock.
3. If the patent log is used, and it is known that the log is accurate, the difference between the first and last reading of log will be distance off fixed object when abeam.

Example:

Reading of log object bearing 4 points	28.6
Reading of log object abeam	37.3
Distance off object when abeam	8.7 miles

NOTE.—It must always be understood that a patent log, no matter how accurate, does not keep a correct run of a ship, as it does not allow for current, consequently, this method cannot absolutely be relied upon.

When the time by clock is used, and the ship's speed over the ground is known, this example is absolutely accurate if the bearings have been taken properly.

RULE:

1. Having time of clock at first and second bearing, subtract less from greater and find number of minutes ship has run between bearings.
2. Multiply the number of minutes run by speed of ship over ground.
3. Divide this result by 60, and the answer will be distance off fixed object when abeam.

PROBLEM NO. 1

A ship is making 14.8 knots per hour. At 5h 48m A. M. a lighthouse bore 4 points on the bow and at 6h 23m A. M. was abeam. Required distance off light when abeam?

Time abeam	6h 23m	35m × 14.8 knots = 518.0
Time 4 points	5h 48m	
Interval	35m	$\frac{518.0}{60}$ = 8.63 distance off lighthouse when abeam

PROBLEM NO. 2

A ship is steering S 45° E. At 6h 40m P. M. a light vessel bore S and at 7h 29m P. M. bore S 45° W. Ship's speed over ground 14.6 knots until 7h 0m P. M., then reduced to 12.3 knots. Required distance off light vessel when abeam?

Time 4 points	6h 40m	20m × 14.6 knots = 292.0
Time speed reduced	7h 0m	
Interval	20m at 14.6 knots	$\frac{292.0}{60}$ = 4.87 distance run on first speed
Time speed reduced	7h 0m	29m × 12.3 knots = 356.7
Time vessel abeam	7h 29m	
Interval	29m at 12.3 knots	$\frac{356.7}{60}$ = 5.94 distance run on second speed

4.87 + 5.94 = 10.81 miles distance off light vessel when abeam

PROBLEM NO. 3

A ship is steering N 23° E. Set of current S 54° W 2½ knots per hour. Speed of ship through water 14.3 knots per hour. At 9h 21m P. M. a lighthouse bore N 68° E and at 10h 18m P. M. bore S 67° E. Required distance off lighthouse when abeam?

Time 4 points	9h 21m	14.3 knots per hour speed of ship through water
Time abeam	10h 18m	2.25 knots per hour set of current against or –
Interval	57m	12.05 knots per hour speed of ship over ground

57m × 12.05 knots = 686.85 $\frac{686.85}{60}$ = 11.45 distance off lighthouse when abeam

PROBLEM NO. 4

A ship is steering S 35° W. Set of current S 45° W 2.5 knots per hour. Speed of ship through water 12.8 knots per hour. At 1h 14m A. M. a lighthouse bore S 80° W and at 2h 12m A. M. bore N 55° W. Required distance off lighthouse when abeam?

Time 4 points	1h 14m	12.8 knots per hour speed of ship through water
Time abeam	2h 12m	2.5 knots per hour set of current fair or +
Interval	58m	15.3 knots per hour speed of ship over ground

$58\text{m} \times 15.3 \text{ knots} = 887.4$

$\frac{887.4}{60} = 14.8$ miles distance off lighthouse when abeam

CHAPTER VII

SPEED OF SHIP BY WHEEL AND PERCENTAGE OF SLIP

This problem is good for determining the speed of the ship by the engine when the pitch of the wheel is known and the number of revolutions the propeller is making per minute.

It must be remembered that it cannot be absolutely relied upon to determine the distance a ship has actually run or the actual speed of a ship, as it does not allow for current or head seas or for any other cause that may retard or increase the speed of a vessel.

The difference between the run of a ship by observation and the run of a ship by the wheel is called the slip of wheel. It is positive if the engine overruns the ship, and negative if the ship overruns the engine.

RULE: To determine speed of ship by number of revolutions per minute.

1. Multiply number of revolutions per minute by 60, result will be number of revolutions per hour.
2. Multiply this result by the pitch of the wheel.
3. Divide this result by 6080 (the number of feet in a nautical mile or knot).
4. The answer will be the speed of the ship per hour by wheel.

Example:

PROBLEM NO. 1

Pitch of wheel, 23 ft.; number of revolutions per minute, 71. Required speed of ship by wheel?

Revolutions $71 \times 60 = 4260$ revolutions per hour

$4260 \times$ pitch 23 ft. $= 97{,}980$

$\frac{97980}{6080} = 16.1$ knots per hour speed of ship by engine

PROBLEM NO. 2

Pitch of wheel, 22.4 ft.; number of revolutions per minute, 68.3. Required speed of ship by wheel?

Revolutions $68.3 \times 60 = 4098$ revolutions per hour
4098×22.4 pitch $= 91{,}795.2$
$\frac{91795.2}{6080} = 15.1$ knots per hour speed of ship by engine

TO DETERMINE THE PERCENTAGE OF SLIP OF WHEEL

RULE:

1. With the ship's run by observation and the ship's run by wheel, find the difference between them.
2. Multiply this difference by 100.
3. Divide the result by the wheel run.
4. Answer will be slip of wheel.

If the ship's run is larger than the run by wheel, the slip will be negative.

If the run by wheel is larger than the ship's run, the slip will be positive.

PROBLEM NO. 1

A ship runs by observation 300 miles in 24 hours. By wheel 340 miles. Required the slip of the wheel?

Ship's run by observation	300 miles
Ship's run by wheel	340 miles
Difference	40 miles

$40 \text{ miles} \times 100 = 4000$
$\frac{4000}{340} = 11.8\%$ positive slip

PROBLEM NO. 2

A ship runs by observation 296 miles in 24 hours. Run by wheel 290 miles. Required slip of wheel?

Ship's run by observation	296 miles
Ship's run by wheel	290 miles
Difference	6 miles

$6 \text{ miles} \times 100 = 600$
$\frac{600}{290} = 2.07\%$ negative slip

CHAPTER VIII

FUEL CONSERVATION

The rules below will explain themselves in this subject. All the proportions involved have been worked in logarithms, and the rules given in that way.

TO DETERMINE AMOUNT SPEED OF SHIP SHALL BE REDUCED IN ORDER TO MAKE PORT ON THE AMOUNT OF FUEL ON HAND

RULE:

1. From Table 42 (Bowditch) take out log: of speed ship is making.
2. Multiply this log: by 2.
3. Add to this log: the log: of distance there is sufficient fuel for at same speed.
4. Subtract from this log: the log: of distance required to be made.
5. Divide this log by 2.
6. Log: of this remainder will be speed per hour necessary to reduce speed in order to make port with fuel on hand.

PROBLEM NO. 1

The full speed of a steamer is 14 knots per hour. She is 525 miles from her destination and has enough fuel to make 360 miles at full speed. At what reduced speed shall she steam in order to make port?

Log: of speed 14 knots	1.14613
Multiply by 2	2
	2.29226
Log: of distance there is sufficient fuel at same speed	2.55630
	4.84856
Distance required to be made: Log: 525	2.72016
Divide by 2	2.12840
Log:	1.06420 = 11.6

Speed necessary to reduce to 11.6 knots per hour.

PROBLEM NO. 2

A steamer is 1215 miles from her destination and has enough fuel to steam 830 miles at a speed of 10 knots. To what must she reduce her speed in order to reach destination?

Log: of speed 10 knots	1.00000
Multiply by 2	2
	2.00000
Log: of distance there is sufficient fuel at same speed 830 miles	2.91908
	4.91908
Distance required to be made: Log: 1215	3.08458
Divide by 2	1.83450
Log:	0.91725 = 8.27

Speed necessary to reduce to 8.27 knots per hour.

TO DETERMINE REVOLUTIONS PER MINUTE TO CONSUME A CERTAIN AMOUNT OF FUEL: THE AMOUNT OF FUEL CONSUMPTION BEING KNOWN ON CERTAIN REVOLUTIONS

RULE:

1. From Table 42 take log: of revolutions per minute engines are making and on which fuel consumption is known.
2. Multiply this log: by 3.
3. Add to this log: the log: of fuel it is desired to know the amount of revolutions necessary in order to consume.
4. Subtract from this log: the log: of fuel consumed known at certain revolutions.
5. Divide this log: by 3.
6. Log: of remainder will be amount or revolutions necessary to make in order to consume amount of fuel stated.

PROBLEM NO. 1

A steamer's engines at 78 revolutions per minute consume 6.5 tons of fuel per hour. How many revolutions must she make to consume 4¼ tons per hour?

Log: revolutions per minute consumption is known 78	1.89209
Multiply by 3	3
	5.67627
Log: fuel it is desired to know the amount of revolutions necessary in order to consume 4.25	0.62839
	6.30466
Log: of known consumption 6.5	0.81291
Divide by 3	5.49175
Log:	1.83058 = 67.7

Revolutions per minute to consume 4¼ tons per hour 67.7.

PROBLEM NO. 2

A steamer's engines at 66 revolutions per minute consume 4¾ tons per hour. How many revolutions will she make consuming 8 tons per hour?

Log: revolutions per minute consumption is known 66	1.81954
Multiply by 3	3
	5.45862
Log: fuel it is desired to know the amount of revolutions necessary in order to consume 8	0.90309
	6.36171
Log: of known consumption 4.75	0.67669
Divide by 3	5.68502
Log:	1.89501 = 78.53

Revolutions per minute to consume 8 tons per hour 78.53.

TO DETERMINE DISTANCE ON FUEL CONSUMPTION AT REDUCED OR INCREASED SPEEDS

RULE:

1. From Table 42 take out log: of speed steamer is making.
2. Multiply this log: by 2.
3. Add to this log:
   Log: of distance covered at original speed.
   Log: fuel to be consumed in distance to be found.

4. Subtract from this log: the log: of fuel consumed at original speed.
5. Subtract from this log: the log: (multiplied by 2) of speed fuel consumption is desired to be known on.
6. Log: that agrees with this log: will be distance desired to be known.

PROBLEM NO. 1

Steaming at a speed of 12 knots a steamer has gone 960 miles and consumed 143 tons of fuel. How far can she steam at a speed of 9 knots and consume 96 tons of fuel.

Log: of speed steamer is making 12	1.07918
Multiply by 2	2
	2.15836
Log: of distance covered at original speed 960	2.98227
Log: of fuel to be consumed 96	1.98227
	7.12290
Log: of fuel consumed 143	2.15534
	4.96756
Log: of speed to be made 9 = 0.95424 × 2	1.90848
Log:	3.05908 = 1145.7

Distance can steam 1145.7 miles.

PROBLEM NO. 2

Steaming at a speed of 13 knots a steamer has gone 1285 miles and consumed 181 tons of fuel. How far can she steam at a speed of 14 knots and consume 181 tons of fuel?

Log: of speed steamer is making 13	1.11394
Multiply by 2	2
	2.22788
Log: of distance covered at original speed 1285	3.10890
Log: of fuel to be consumed 181	2.25768
	7.59446
Log: of fuel consumed 181	2.25768
	5.33678
Log: of speed to be made 14 = 1.14613 × 2	2.29226
Log:	3.04452 = 1108

Distance can steam 1108 miles.

TO DETERMINE AMOUNT SPEED MUST BE REDUCED IN ORDER TO CONSERVE FUEL AND REACH PORT WITH A SAFE MARGIN

RULE:

1. From Table 42 take out log: of speed ship has been making.
2. Multiply this log: by 2.
3. Add to this log:
   Log: of distance already made.
   Log: of fuel remaining, less the amount desired to arrive in port with.
4. Subtract from this log: the log: of the amount of fuel already used.
5. Subtract from this log: the log: of the distance remaining to go.
6. Divide this log: by 2.
7. Log: that agrees will be speed necessary to make in order to reach port.

PROBLEM NO. 1

On a voyage of 2561 miles a steamer has gone 1281 miles at a speed of $10\frac{3}{4}$ knots per hour and consumed 186 tons of fuel. There remain 118 tons of fuel. At what speed must the vessel steam to reach port and have 15 tons of fuel left on arrival?

Log: of speed vessel has been making 10.75	1.03141
Multiply by 2	2
	2.06282
Log: of distance made 1281	3.10755
Log: of fuel remaining 118 − 15 tons = 103	2.01284
	7.18321
Log: of fuel used 186	2.26951
	4.91370
Log: of distance to go 2561 − 1281 = 1280	3.10721
Divide by 2	1.80649
Log:	0.90324 = 8

Speed to steam 8 knots.

PROBLEM NO. 2

On a voyage of 3031 miles a steamer has gone 2376 miles at a speed of 11.5 knots per hour and consumed 281 tons of fuel. There remain 100 tons of fuel. At what speed could the vessel steam to reach port and have 15 tons of fuel on arrival?

Log: of speed vessel has been making 11.5	1.06070
Multiply by 2	2
	2.12140
Log: of distance made 2376	3.37585
Log: of fuel remaining 100 − 15 tons = 85	1.92942
	7.42667
Log: of fuel consumed 281	2.44871
	4.97796
Log: of distance to go 3031 − 2376 = 655	2.81624
Log: Divide by 2	2.16172
Log:	1.08086 = 12.04

Speed to steam 12.04 knots.

CHAPTER IX

CONSTRUCTION OF A MERCATOR CHART

A Mercator Chart is constructed on the principle that the earth is a flat surface instead of a sphere, and is by far the most generally used for navigation purposes.

At the equator a degree of longitude is equal to a degree of latitude, but in receding from the equator and approaching the pole, while the degrees of latitude remain always of the same length (save for a slight change due to the fact that the earth is not a perfect sphere), the degrees of longitude become less and less.

Since, in the Mercator Projection, the degrees of longitude are made to appear everywhere of the same length, it becomes necessary, in order to preserve the proportion that exists at different parts of the earth's surface between degrees of latitude and degrees of longitude, that the former be increased from their natural lengths, and such increase must become greater and greater the higher the latitude.

The length of the meridian, as thus increased, between the equator and any given latitude, expressed in minutes at the equator as a unit,constitutes the number of meridional parts corresponding to that latitude. Table 3 (Bowditch) is the table of meridional parts.

As the Mercator Projection is a distortion of the earth's surface it is plainly to be seen that a straight line drawn between two places on a Mercator Chart is not the shortest distance between them. As already explained in Chapter II the shortest distance between any two points is a Great Circle, as this follows the true lines of the earth's surface. On a Great Circle course the ship is always headed for her port of destination, whereas on a Mercator course she is never headed for it until she is close to her destination.

If the chart for which a projection is to be made includes the equator, the values to be measured off are given directly by Table 3. If the equator does not come upon the chart then the parallels of latitude to be laid down should be referred to a principal parallel, preferably the lowest paral-

lel to be drawn on the chart. The distance of any other parallel of latitude from the principal parallel is then the difference of the values for the two taken from Table 3.

In adapting the scale to be used for the Projection, it is generally desirable to select a sheet of paper large enough to protect against the scale being so small as to make the chart unworkable. It is at times necessary, though, if the size of paper is limited, and the chart is needed to cover a large surface, that the scale be small.

In the following illustration the length of space between lowest and highest parallel of latitude, approximately 5°, is 18 inches. This gives a fairly good workable chart.

We will now proceed with following example and explanation, illustration of which is given.

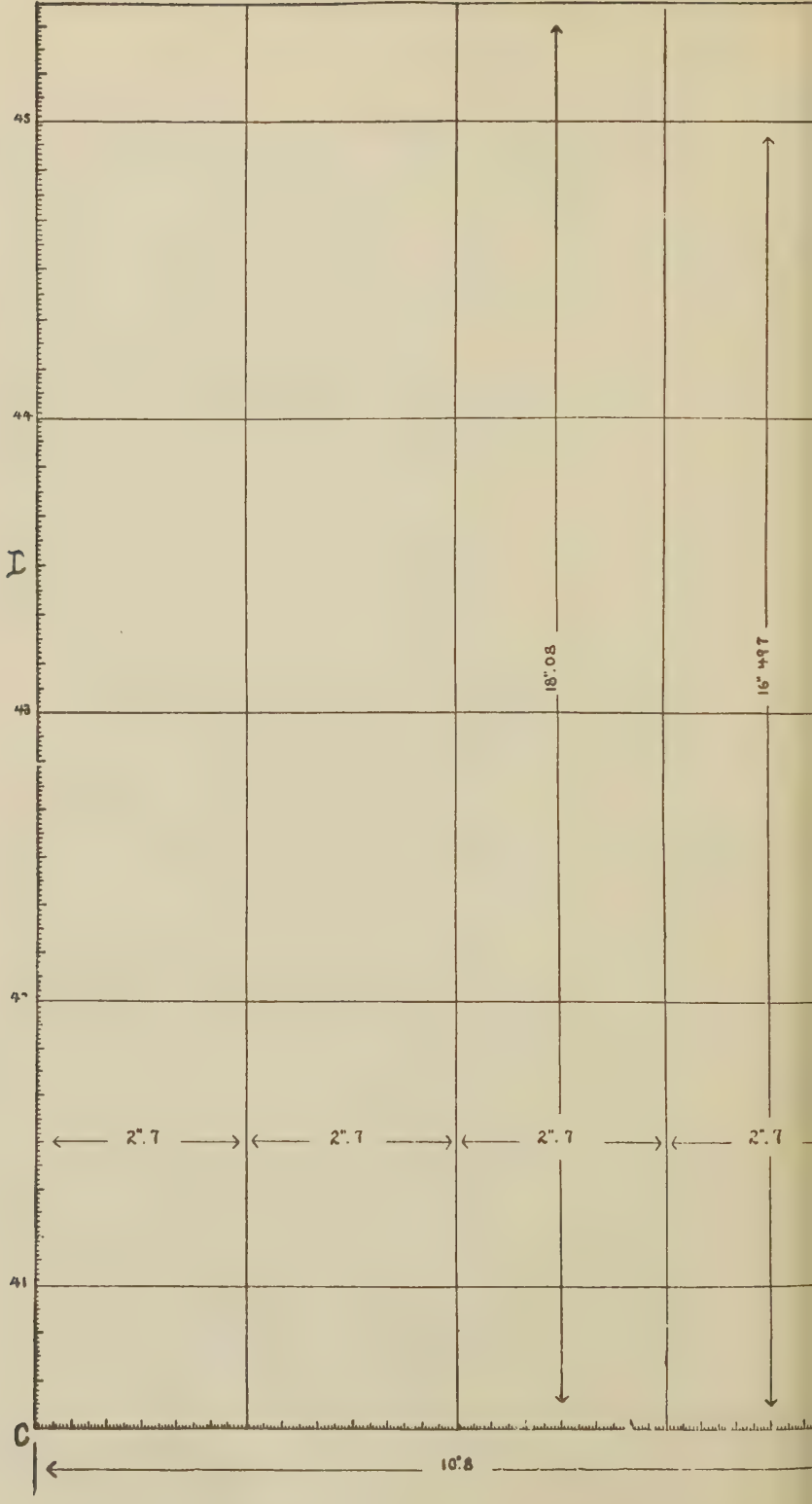
EXAMPLE: Let a Projection be required for a chart of 8° extent in longitude, between the parallels of Lat. 40° 30′ N, and 45° 25′ N, and let the space allowable on the paper between these parallels measure 18 inches.

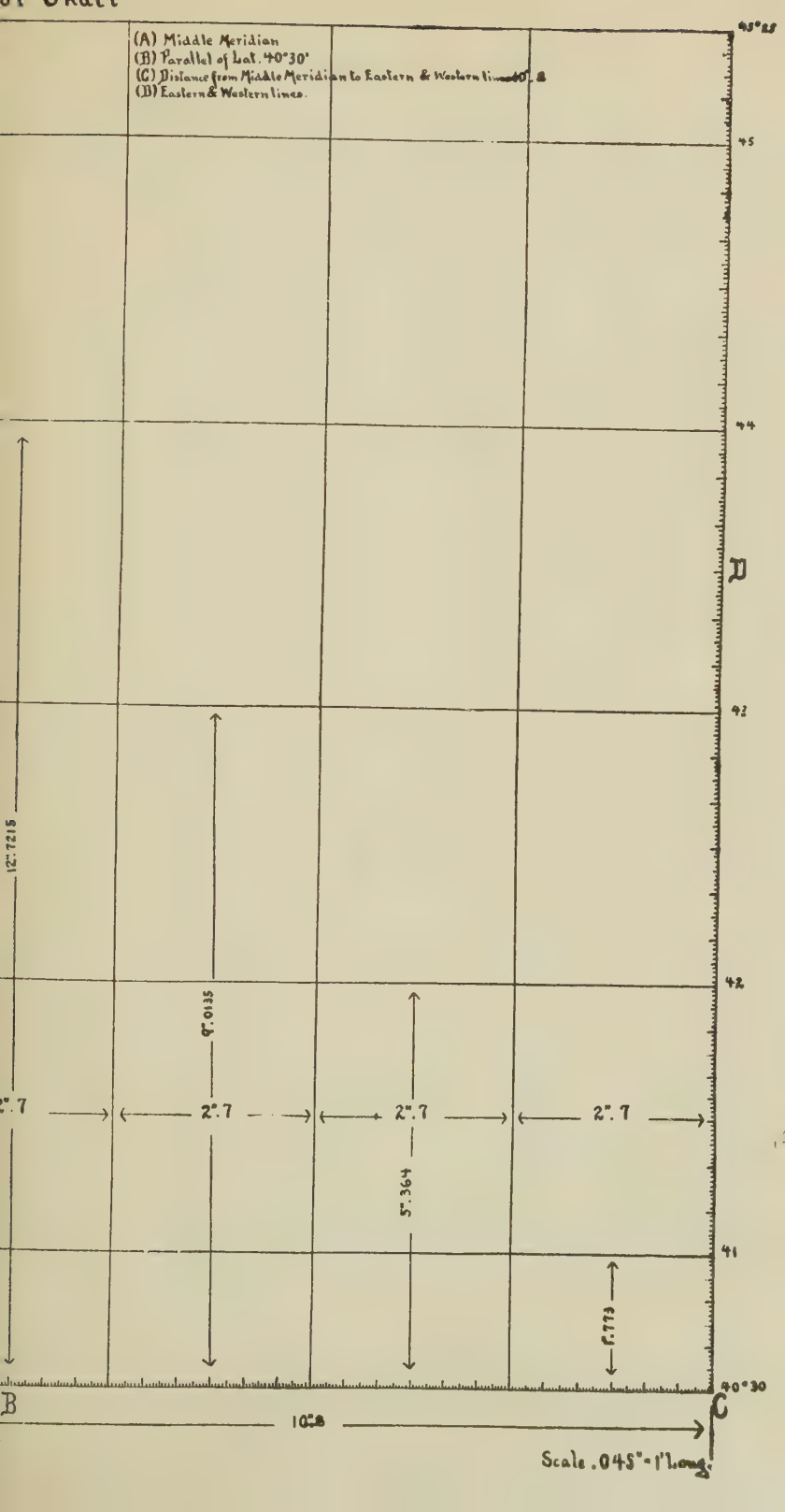
1. Enter Table 3 (Bowditch) and take out the meridional difference of latitude or meridional parts for 40° 30′, the lowest parallel of Lat., which we find is 2646.8. Take out same for highest parallel 45° 25′ = 3048.7 The difference 3048.7 − 2646.8 = 401.9. This is the value of the Meridional Arc between these latitudes.
2. The paper space allowable between lowest and highest parallels being 18 inches we divide 18 inches by 401.9 or $\frac{18 \text{ inches}}{401.9} = 0.0448$ inch, which will be the scale of the chart. We will call same 0.045 inch. Each 1′ of Long. on this chart will therefore measure 0.045 inch.
3. Draw in the center of the sheet a straight line, and assume it to be the middle meridian of the chart (A).
4. At the lower border of the sheet draw a line perpendicular to the first line, and assume this line to be parallel of latitude 40° 30′ (B).
5. From the intersection of the lines lay off on the parallel, on each side of the middle meridian, 4° of Long., or distances equal to $0.045 \times 60 \times 4 = 10.8$ inches (C).
6. From these points draw lines parallel to the middle meridian. These will be the Eastern and Western lines of the chart (D).

$d\omega = \sec \varphi \cdot d\varphi$

$$u = \log \tan\left(\frac{\varphi}{2} + \frac{\pi}{4}\right)$$

transformation between sphere and plane to preserve angles - WRT.


45
44
43
42
41
D
C
18".08
16".497
2".7
2".7
2".7
2".7
10".8


(A) Middle Meridian
(B) Parallel of Lat. 40°30'
(C) Distance from Middle Meridian to Eastern & Western lines 10".8
(D) Eastern & Western lines.
45°25
45
44
43
42
41
40°30
D
12".7215
9".0135
2".7
2".7
2".7
2".7
5".364
1".773
B
C
10".8
Scale .045" = 1' Long.

7. Next we proceed to find the distance between Lat. 40° 30′ and 41° as follows: Enter Table 3 and we find Mer. parts for 40° 30′ equal 2646.8 for 41° equal 2686.2. Thus, 2686.2 − 2646.8 = 39.4 which is value of meridional arc between Latitudes. This value 39.4 × 0.045 inch = 1.773 inches, distance between 40° 30′ and 41°.
8. Measure this distance on the three meridians from the lowest parallel and draw a straight line between them. This line will represent Lat. 41°.
9. Following same rule we find distance between 40° 30′ and 42°. M. D. L. 40° 30′ = 2646.8, for 42° = 2766.0. Thus, 2766.0 − 2646.8 = 119.2 × 0.045 inch = 5.364 inches. Distance between 40° 30′ and 42°.
10. Measure this distance as before from lowest parallel and draw a line representing 42°.
11. The same rule applies until highest parallel is attained, and we find the following distances:

    40° 30′ to 43° = 9.0135 inches.
    40° 30′ to 44° = 12.7215 inches.
    40° 30′ to 45° = 16.497 inches.
    40° 30′ to 45° 25′ = 18.08 inches.

12. The line drawn to represent Lat. 45° 25′ will be the Northern limit of the chart.
13. On the lowest and highest parallel measure from the middle meridian on each side four distances each equal to 2.7 inches and draw lines parallel to middle meridian. These will be the degrees of longitude.
14. Divide each degree of Lat. and Long. into 60 equal parts, and if it is wished the Compass Rose may be drawn. This will complete the construction.

NOTE: It is necessary in constructing a chart that a great deal of care is taken that the lines drawn are exactly true. A good draughtsman's outfit consisting of drawing board, "T" square, 45° and 60° angles, drawing instruments, and a three- (3) cornered measure divided into 10ths, 20ths, 40ths, 50ths, and 60ths of an inch are advisable. With this equipment the problem is very simple, and should be practiced and understood by every deck officer.

See illustration.

CHAPTER X

MERCATOR'S SAILING

This problem is to find the course and distance in a straight line between two places.

The latitude and longitude A is the point of starting, and the latitude and longitude B is the place bound for.

The latitude A and latitude B and longitude A and longitude B are put down under each other, and the difference between the places is found in degrees, minutes and seconds by the following rule:

Both of the same name, subtract. Different name, add the two.

If the degrees of longitude exceed 180°; subtract total from 360°.

The degrees and minutes are turned into minutes by multiplying the degrees by 60, and adding to the result the minutes.

A Mercator chart is constructed on the principle that the earth is a flat plane, and the degrees of longitude are equal, and the degrees of latitude are increased from the equator to the poles to allow for the decrease in the degrees of longitude.

From Table 3 (Bowditch) take out the meridional parts for the degrees and minutes of each latitude.

Add or subtract these meridional parts, same as was done with the degrees and minutes of latitude in the problem.

In Table 42 (Bowditch) will be found logarithms of numbers. All logarithms of numbers have an index number which is found by table below:

2 figures in the distance, the index number is 1.
3 figures in the distance, the index number is 2.
4 figures in the distance, the ndex number is 3.

When the number is of 2 or 3 figures the logarithm is read in the 0 column alongside of the number given.

When the number has 4 figures the first 3 numbers of the figures are read on the side, and the last number at top of page.

Take out from Table 42 logarithm of difference of longi-

tude in minutes, adding 10 to the index number, and logarithm of meridional parts, index number by rule above.

Subtract logarithm of meridional parts from logarithm of difference of longitude.

The Logarithm Tangent in Table 44 (Bowditch) that agrees with answer will be the course in degrees and minutes.

If the index number for Tangent is 8 or 9 the course will be from top of page.

If the index number for Tangent is 10 or 11 the course will be from bottom of page.

Take out the Logarithm Secant from Table 44 for the degrees and minutes of the course, rejecting the 10 from the index number.

Take out the logarithm of difference of latitude (Table 42) applying its index number by rule above.

Add together Logarithm Secant of course, and logarithm of difference of latitude.

The logarithm that agrees with this sum in the body of the logarithms, Table 42, will be the distance in the left-hand column for the first 3 numbers, and the number of the column logarithm was found in on top will be the last number.

If the index number is 1 the distance will be in 2 figures.
If the index number is 2 the distance will be in 3 figures.
If the index number is 3 the distance will be in 4 figures.

PROBLEM NO. 1

Lat. A 43° 08′ N	Mer. Parts 2858.0	Long. A 5° 56′ E
Lat. B 39° 29′ N	Mer. Parts 2567.5	Long. B 0° 24′ W
3° 39′	290.5	6° 20′
60		60
180		360
+ 39		+ 20
D. L. 219	Diff. Lon.	380

Log. of Diff. Long. 380 = 12.57978
Log. of Mer. Parts 290.5 = 2.46315

Tangent 10.11663 = Course S 52°36′ W
Secant of Course 52° 36′ = 0.21654
Log. of Diff. Lat. 219 = 2.34044

Log. 2.55698 = Dist. 360.6 miles

PROBLEM NO. 2

Lat. A 15° 55′ S Mer. Parts 961.1 Long. A 5° 44′ W
Lat. B 55° 59′ S Mer. Parts 4052.7 Long. B 67° 16′ W

Diff. Lat. 2404′ Mer. Parts 3091.6 Diff. Long. 3692′

Log. of Diff. Long. 3692 = 13.56726
Log. of Mer. Parts 3092 = 3.49024

Tangent 10.07702 = Course S 50° 03′ W

Secant of Course 50° 03′ = 0.19238
Log of Diff. Lat. 2404 = 3.38093

Log. 3.57331 = Dist. 3744 miles

PROBLEM NO. 3

Lat. A 15° 12′ S Mer. Parts 916.8 Long. A 2° 12′ E
Lat. B 28° 49′ S Mer. Parts 1795.6 Long. B 17° 11′ E

Diff. Lat. 817′ S Mer. Parts 878.8 Diff. Long. 899′

Log. of Diff. Long. 899 = 12.95376
Log. of Mer. Parts 878.8 = 2.94389

Tangent 10.00987 = Course S 45° 39′ E

Secant of Course 45° 39′ = 0.15550
Log. of Diff. Lat. 817′ = 2.91222

Log. 3.06772 = Dist. 1169 miles

PROBLEM NO. 4

Lat. A 17° 15′ S Mer. Parts 1044.1 Long. A 92° 21′ W
Lat. B 31° 42′ S Mer. Parts 1994.9 Long. B 110° 10′W

Diff. Lat. 867′ Mer. Parts 950.8 Diff. Long. 1069′

Log. of Diff. Long. 1069 = 13.02898
Log. of Mer. Parts 950.8 = 2.97809

Tangent 10.05089 = Course S 48° 21′W

Secant of Course 48° 21′ = 0.17745
Log. of Diff. Lat. 867 = 2.93802

Log. 3.11547 = Dist. 1305 miles

PROBLEM NO. 5

Lat. A 18° 12′ S Mer. Parts 1103.5 Long. A 18° 10′ E
Lat. B 46° 11′ S Mer. Parts 3114.5 Long. B 32° 21′ W

Diff. Lat. 1679′ Mer. Parts 2011 Diff. Long. 3031′

Log. of Diff. Long. 3031 = 13.48159
Log. of Mer. Parts 2011 = 3.30341

Tangent 10.17818 = Course S 56° 26′ W

Secant of Course 56° 26′ = 0.25735
Log. of Diff. Lat. 1679 = 3.22505

Log. 3.48240 = Dist. 3037 miles

PROBLEM NO. 6

Lat. A 30° 29′ N Mer. Parts 1910.1 Long. A 179° 47′ E
Lat. B 15° 12′ N Mer. Parts 916.8 Long. B 126° 44′ E

Diff. Lat. 917′ Mer. Parts 993.3 Diff. Long. 3183′

Log. of Diff. Long. 3183 = 13.50284
Log. of Mer. Parts 993.3 = 2.99708

Tangent 10.50576 = Course S 72° 40′ W

Secant of Course 72° 40′ = 0.52589
Log. of Diff. Lat. 917 = 2.96237

Log. 3.48826 = Dist. 3078 miles

PROBLEM NO. 7

Lat. A 8° 05′ S Mer. Parts 483.3 Long. A 18° 02′ W
Lat. B 62° 04′ S Mer. Parts 4762.8 Long. B 103° 03′ W

Diff. Lat. 3239′ Mer. Parts 4279.5 Diff. Long. 5101′

Log. of Diff. Long. 5101 = 13.70766
Log. of Mer. Parts 4279 = 3.63134

Tangent 10.07632 = Course S 50° 01′ W

Secant of Course 50° 01′ = 0.19208
Log. of Diff. Lat. 3239 = 3.51041

Log. 3.70249 = Dist. 5041 miles

PROBLEM NO. 8

Lat. A 0° 00′	Mer. Parts 0000.0	Long. A 0° 02′ W
Lat. B 51° 12′ N	Mer. Parts 3569.7	Long. B 16° 14′ E
Diff. Lat. 3072′	Mer. Parts 3569.7	Diff. Long. 976′

Log. of Diff. Long.	976 =	12.98945
Log. of Mer. Parts	3570 =	3.55267
Tangent		9.43678 = Course N 15° 17′ E
Secant of Course	15° 17′ =	0.01564
Log. of Diff. Lat.	3072 =	3.48742
Log.		3.50306 = Dist. 3185 miles

PROBLEM NO. 9

Lat. A 71° 02′ S	Mer. Parts 6129.7	Long. A 16° 12′ E
Lat. B 22° 05′ S	Mer. Parts 1350.3	Long. B 102° 15′ E
Diff. Lat. 2937′	Mer. Parts 4779	Diff. Long. 5163′

Log. of Diff. Long.	5163 =	13.71290
Log. of Mer. Parts	4779 =	3.67934
Tangent		10.03356 = Course N 47° 13′ E
Secant of Course	47° 13′ =	0.16798
Log. of Diff. Lat.	2937 =	3.46790
Log.		3.63588 = Dist. 4324 miles

PROBLEM NO. 10

Lat. A 14° 12′ S	Mer. Parts 855.1	Long. A 178° 02′ E
Lat. B 79° 02′ S	Mer. Parts 8033.2	Long. B 115° 16′ W
Diff. Lat. 3890′	Mer. Parts 7178.1	Diff. Long. 4002′

Log. of Diff. Long.	4002 =	13.60228
Log. of Mer. Parts	7178 =	3.85600
Tangent		9.74628 = Course S 29° 08′ E
Secant of Course	29° 08′ =	0.05877
Log. of Diff. Lat.	3890 =	3.58995
Log.		3.64872 = Dist. 4454 miles

PROBLEM NO. 11

Lat. A 3° 12′ N	Mer. Parts 190.8	Long. A 118° 00′W
Lat. B 79° 15′ N	Mer. Parts 8102.2	Long. B 142° 12′W
Diff. Lat. 4563′	Mer. Parts 7911	Diff. Long. 1452′

Log. of Diff. Long.	1452 = 13.16197	
Log. of Mer. Parts	7911 = 3.89823	
Tangent =	9.26374	= Course N 10° 24′ W
Secant of Course	10° 24′ = 0.00719	
Log. of Diff. Lat.	4563 = 3.65925	
Log. =	3.66644	= Dist. 4639 miles

PROBLEM NO. 12

Lat. A 19° 36′ N	Mer. Parts 1191.8	Long. A 18° 12′ E
Lat. B 21° 42′ S	Mer. Parts 1325.6	Long. B 2° 06′ W
Diff. Lat. 2478′	Mer. Parts 2517	Diff. Long. 1218′

Log. of Diff. Long.	1218 = 13.08565	
Log. of Mer. Parts	2517 = 3.40088	
Tangent	9.68477	= Course S 25° 49′W
Secant of Course	25° 49′ = 0.04566	
Log. of Diff. Lat.	2478 = 3.39410	
Log.	3.43976	= Dist. 2753 miles

PROBLEM NO. 13

Lat. A 36° 08′ N	Mer. Parts 2314.1	Long. A 159° 00′ E
Lat. B 17° 17′ S	Mer. Parts 1046.1	Long. B 159° 00′W
Diff. Lat. 3205′	Mer. Parts 3360	Diff. Long. 2520′

Log. of Diff. Long.	2520 = 13.40140	
Log. of Mer. Parts	3360 = 3.52634	
Tangent	9.87506	= Course S 36° 52′ E
Secant of Course	36° 52′ = 0.09689	
Log. of Diff. Lat.	3205 = 3.50583	
Log.	3.60272	= Dist. 4006 miles

PROBLEM NO. 14

Lat. A 9° 18′ S	Mer. Parts 556.7	Long. A 74° 13′ E	
Lat. B 42° 17′ S	Mer. Parts 2788.9	Long. B 47° 17′ E	
Diff. Lat. 1979′	Mer. Parts 2232.2	Diff. Long. 1616′	
Log. of Diff. Long.	1616 = 13.20844		
Log. of Mer. Parts	2232 = 3.34869		
	Tangent 9.85975	= Course S 35° 54′W	
Secant of Course	35° 54′ = 0.09149		
Log. of Diff. Lat.	1979 = 3.29645		
	Log. 3.38794	= Dist. 2443 miles	

PROBLEM NO. 15

Lat. A 14° 06′ N	Mer. Parts 849.0	Long. A 81° 59′ W	
Lat. B 32° 55′ N	Mer. Parts 2080.8	Long. B 59° 17′ W	
Diff. Lat. 1129′	Mer. Parts 1232	Diff. Long. 1362′	
Log. of Diff. Long.	1362 = 13.13418		
Log. of Mer. Parts	1232 = 3.09061		
	Tangent 10.04357	= Course N 47° 52′E	
Secant of Course	47° 52′ = 0.17337		
Log. of Diff. Lat.	1129 = 3.05269		
	Log. 3.22606	= Dist. 1683 miles	

PROBLEM NO. 16

Lat. A 0° 06′ N	Mer. Parts 6.0	Long. A 0° 00′	
Lat. B 60° 10′ N	Mer. Parts 4527.1	Long. B 41° 02′ W	
Diff. Lat. 3604′	Mer. Parts 4521	Diff. Long. 2462′	
Log. of Diff. Long.	2462 = 13.39129		
Log. of Mer. Parts	4521 = 3.65523		
	Tangent 9.73606	= Course N 28° 34′ W	
Secant of Course	28° 34′ = 0.05638		
Log. of Diff. Lat.	3604 = 3.55678		
	Log. 3.61316	= Dist. 4103 miles	

PROBLEM NO. 17

Lat. A 34° 22′ S	Mer. Parts 2184.9	Long. A 18° 24′ E
Lat. B 15° 55′ S	Mer. Parts 961.1	Long. B 5° 45′ W
Diff. Lat. 1107′	Mer. Parts 1224	Diff. Long. 1449′

Log. of Diff. Long.	1449 =	13.16107
Log. of Mer. Parts	1224 =	3.08778
Tangent		10.07329 = Course N 49° 49′ W
Secant of Course	49° 49′ =	0.19028
Log. of Diff. Lat.	1107 =	3.04415
Log.		3.23443 = Dist. 1716 miles

PROBLEM NO. 18

Lat. A 8° 04′ S	Mer. Parts 482.3	Long. A 34° 53′ W
Lat. B 14° 45′ N	Mer. Parts 889.0	Long. B 17° 32′ W
Diff. Lat. 1369′	Mer. Parts 1371	Diff. Long. 1041′

Log. of Diff. Long.	1041 =	13.01745
Log. of Mer. Parts	1371 =	3.13704
Tangent		9.88041 = Course N 37° 12′E
Secant of Course	37° 12′ =	0.09880
Log. of Diff. Lat.	1369 =	3.13640
Log.		3.23520 = Dist. 1719 miles

CHAPTER XI

MIDDLE LATITUDE SAILING

This method is to find the course and distance between two places, when the distance is small.

Proceed as in Mercator's sailing to find the difference of latitude and longitude in minutes.

Find the Middle Latitude between the places as in Day's Work.

Take the Middle Latitude to the nearest degree as a course, and in Table 2 (Bowditch) look in the Distance column for the difference of longitude in minutes, and in the latitude column corresponding to this distance will be the Departure in miles.

Compare the difference of latitude in miles and departure in miles in Table 2, and the course and distance will be found as in Day's Work.

Never cross the equator with this method.

PROBLEM NO. 1

Lat. A 28° 17′ N	28° 17′	Long. A	14° 16′ W
Lat. B 30° 02′ N	30° 02′	Long. B	23° 10′ W
1° 45′	58° 19′		8° 54′

Diff. Lat. 105′ or 105 miles

29° 09′ Mid. Lat.

Diff. Long. 534′

Departure 467 miles

Course N 77° W. Distance 479 miles.

PROBLEM NO. 2

Lat. A 38° 16′ S	38° 16′	Long. A	102° 12′ E
Lat. B 40° 12′ S	40° 12′	Long. B	108° 11′ E
1° 56′	78° 28′		5° 59′

Diff. Lat. 116′ or 116 miles

39° 14′ Mid. Lat.

Diff. Long. 359′

Departure 279.0 miles

Course S 67° E. Distance 302 miles.

PROBLEM NO. 3

Lat. A 76° 08′ S	76° 08′	Long. A 179° 53′ E	
Lat. B 74° 16′ S	74° 16′	Long. B 178° 10′ W	
1° 52′	150° 24′		1° 57′
Diff. Lat. 112′	75° 12′ Mid. Lat.		
or 112 miles		Diff. Long. 117′	
		Departure 30.3 miles	

Course N 15° E. Distance 116 miles.

PROBLEM NO. 4

Lat. A 42° 08′ N	42° 08′	Long. A 18° 23′ E	
Lat. B 47° 05′ N	47° 05′	Long. B 21° 06′ E	
4° 57′	89° 13′		2° 43′
Diff. Lat. 297′	44° 36′ Mid. Lat.		
or 297 miles		Diff. Long. 163′	
		Departure 115.3 miles	

Course N 21° E. Distance 318 miles.

PROBLEM NO. 5

Lat. A 51° 53′ N	51° 53′	Long. A 37° 18′ W	
Lat. B 56° 18′ N	56° 18′	Long. B 40° 17′ W	
4° 25′	108° 11′		2° 59′
Diff. Lat. 265′	54° 05′ Mid. Lat.		
or 265 miles		Diff. Long. 179′	
		Departure 105.2 miles	

Course N 22° W. Distance 285 miles.

PROBLEM NO. 6

Lat. A 43° 10′ S	43° 10′	Long. A 108° 00′ W	
Lat. B 40° 08′ S	40° 08′	Long. B 109° 40′ W	
3° 02′	83° 18′		1° 40′
Diff. Lat. 182′	41° 39′ Mid. Lat.		
or 182 miles		Diff. Long. 100′	
		Departure 74.3 miles	

Course N 22° W. Distance 197 miles.

PROBLEM NO. 7

Lat. A	12° 13′ S	12° 13′	Long. A	14° 18′ E
Lat. B	9° 16′ S	9° 16′	Long. B	17° 03′ E
	2° 57′	21° 29′		2° 45′
Diff. Lat.	177′	10° 44′ Mid. Lat.		

Diff. Long. 165′
Departure 162.0 miles

True course N 42° E. Distance 240 miles.

PROBLEM NO. 8

Lat. A	49° 06′ N	49° 06′	Long. A	179° 15′ E
Lat. B	51° 10′ N	51° 10′	Long. B	179° 32′ W
	2° 04′	100° 16′		1° 13′
Diff. Lat.	124′	50° 08′ Mid. Lat.		

Diff. Long. 73′
Departure 46.9 miles

Course N 21° E. Distance 133 miles.

PROBLEM NO. 9

Lat. A	38° 07′ N	38° 07′	Long. A	13° 12′ E
Lat. B	36° 51′ N	36° 51′	Long. B	19° 06′ E
	1° 16′	74° 58′		5° 54′
Diff. Lat.	76′	37° 29′ Mid. Lat.		

Diff. Long. 354′
Departure 282.7 miles

Course S 75° E. Distance 292 miles.

PROBLEM NO. 10

Lat. A	14° 28′ S	14° 28′	Long. A	0° 06′ W
Lat. B	10° 19′ S	10° 19′	Long. B	7° 18′ E
	4° 09′	24° 47′		7° 24′
Diff. Lat.	249′	12° 23′ Mid. Lat.		

Diff. Long. 444′
Departure 434.3 miles

Course N 60° E. Distance 500 miles.

PROBLEM NO. 11

Lat. A	6° 14′ N	6° 14′	Long. A	28° 13′ E
Lat. B	14° 16′ N	14° 16′	Long. B	26° 09′ E
	8° 02′	20° 30′		2° 04′

Diff. Lat. 482′ 10° 15′ Mid. Lat.

Diff. Long. 124′

Departure 122.1 miles

Course N 14° W. Distance 497 miles.

PROBLEM NO. 12

Lat. A	60° 10′ N	60° 10′	Long. A	4° 16′ W
Lat. B	58° 11′ N	58° 11′	Long. B	6° 18′ W
	1° 59′	118° 21′		2° 2′

Diff. Lat. 119′ 59° 10′ Mid. Lat.

Diff. Long. 122′

Departure 62.8 miles

Course S 28° W. Distance 135 miles.

CHAPTER XII

GREAT CIRCLE SAILING

In this chapter are given the methods of determining great circle courses; great circle distance; and latitude and longitude of great circle vertex.

In using the methods for determining courses it is only necessary to use the chart in order to determine whether the great circle will lead across land or in dangerous waters. In such a case a certain position should be fixed on as a limit for the great circle, and then another great circle from that position to point of destination.

The following example will explain the various operations:

PROBLEM NO. 1

Required initial and second great circle course by Time Azimuth and Computation by Logarithm Methods, Great Circle distance by Cosine-Haversine and Logarithm Methods, and the position of great circle vertex from a point off Cape Hatteras in Lat. 35° N, Long. 73° W, to a point off Cape St. Vincent in Lat. 37° N, Long. 9° W?

THE TIME AZIMUTH METHOD OF DETERMINING GREAT CIRCLE COURSES

A ship when sailing on a great circle course is always heading for her port of destination, while when sailing on a Mercator course she is never headed for her destination until at the end of her voyage. In order to keep on the great circle track it is necessary to alter the course at various intervals. As the difference of longitude decreases in approaching destination, so also will the hour angle, and as the hour angle decreases the greater will be the change in azimuth. Therefore, in determining the distance to be run on each course, the change of azimuth will have to be taken into consideration, and the distance run on each course reduced accordingly.

When approaching the destination, and the hour angle becomes less than 1 hour, in order to avoid the intricate interpolations that will be necessary for a small hour angle it is more practical to extend the great circle line beyond the point of destination by projecting it on a great circle chart.

For example: In Problem 1 the destination may be extended to Lat. 25° 20′ N, Long. 19° E.

RULE:

With the latitude of departure as the latitude.

With the latitude of destination as the declination.

With the difference of longitude between departure and destination as the hour angle.

Enter the azimuth table, and the azimuth obtained will be the initial or first (*true*) course.

NOTE.—The latitude of destination as the declination will remain constant for all courses.

Example:

Lat. Dep. 35° N

Long. Dep. 73° W
Long. Dest. 9° W

Diff. Long. 64° = H. A. 4h 16m

Enter Az. Table at Lat. 35°. Dec. 37°. H. A. 4h 16m = 67° 51′ or 68°. Initial or first (true) course is 68°.

As the change in the azimuth is small on the first course we will assume the distance run on this course to be 100 miles.

Entering Table 2 (Bowditch) we find for course 68° Dist. 100 = Diff. Lat. 37.5 N, Dep. 92.7, Diff. Long. 113′ E.

Lat. Left.	35° 0′ 0″ N	Long. Left	73° 0′ W
Diff. Lat.	37′ 30″ N	Diff. Long.	1° 53′ E
Lat. In.	35° 37′ 30″ N	Long. In.	71° 7′ W = Dep. for 2d Course

Second Course

Lat. Dep. 35° 37′

Long. Dep. 71° 7′ W
Long. Dest. 9° 0′ W

Diff. Long. 62° 7′ = H. A. 4h 8m.5

Az. Lat. 35° 37′, Dec. 37°, H. A. 4h 8m = Second Course 69° 4′ or 69°.

This same method applies for finding all other courses, the distance run on each course to be governed by the change in azimuth. In other words, if the azimuth changes more than a degree in a run of 100 miles, reduce the distance on the course to 80 miles, or to any distance that will keep the azimuth changing approximately 1°.

THE METHOD OF DETERMINING GREAT CIRCLE COURSES BY LOGARITHMS

RULE:

1. Under the position of departure, place the position of destination.
2. Find the difference of longitude between departure and destination.
3. Add together the following logs.:
   Log. Cosine of difference of longitude.
   Log. Cotangent of latitude of destination.
4. Log. Tangent of this sum will equal the Auxiliary Angle (ϕ).
5. When the latitude of departure and destination are same names, add the latitude of departure to ϕ.
   When of contrary names, subtract the two.
6. Add together:
   Log. Cosecant of ϕ.
   Log. Cosine of sum or difference of ϕ and latitude of departure.
   Log. Cotangent of difference of longitude.
7. The Log. Cotangent of the sum will be the Initial or first (true) course.

Example:

Lat. Dep.	35° N	Long. Dep.	73° W
Lat. Dest.	37° N	Long. Dest.	9° W
		Diff. Long.	64°

Log. Cosine Diff. Long. 64°	=9.64184		
Log. Cotang. Lat. Dest. 37°	= .12289		
Tangent	9.76473	=ϕ(Aux. Angle)	30° 11′ 18″
		Lat. Dep.	+35° 0′ 0″
		Sum	65° 11′ 18″
Log. Cosec. ϕ 30° 11′ 18″	= .29857		
Log. Cosine Sum 65° 11′ 18″	=9.62288		
Log. Cotang. Diff. Long. 64°	=9.68818		
Cotangent	9.60963	=Initial Course	67° 51′

TO FIND DEPARTURE FOR SECOND COURSE

Assuming distance run on initial course as 100 miles on account of small change in azimuth, we find:

Table 2, Course 68°. Dist. 100 = Diff. Lat. 37.5 N. Dep. 92.7, Diff. Long. 113′ E.

Lat. Dep.	35° 0′ 0″ N	Long. Dep.	73° 0′ W
Diff. Lat.	37′ 30″ N	Diff. Long.	1° 53′ E
Lat. In.	35° 37′ 30″ N	Long. In.	71° 7′ W = Dep. for 2d Course

Second Course

Lat. Dep.	35° 37′ 30″ N	Long. Dep.	71° 7′ W
Lat. Dest.	37° 0′ 0″ N	Long. Dest.	9° 0′ W
		Diff. Long.	62° 7′

Log. Cosine Diff. Long. 62° 7′ = 9.66994
Log. Cotang. Lat. Dest. 37° = .12289

Tangent 9.79283 = ϕ 31° 49′ 30″
Lat. Dep. +35° 37′ 30″
Sum 67° 27′ 0″

Log. Cosec. ϕ 31° 49′ 30″ = .27792
Log. Cosine Sum 67° 27′ = 9.58375
Log. Cotang. D. Long. 62° 7′ = 9.72354

Cotangent = 9.58521 = Second Course 68° 57′

The balance of the courses is determined by this method by allowing for distance run on each course, and using new departure for next course.

It must be remembered that all courses by these methods are *true courses*, and in order to make them it is necessary to allow in the proper direction the deviation and variation of compass.

TO FIND GREAT CIRCLE DISTANCE BY LOGARITHMS

RULE:

1. Add together:
   Log. Tangent of sum or difference of Aux. Angle (ϕ) and latitude of departure.
   Log. Cosine of initial course.
2. Log. Cotangent of sum will be the angular distance.

3. Reduce angular distance to minutes, and the result will be the distance between any two points on the great circle, or the shortest distance between them.

Example:

Log. Tangent Sum (ϕ Lat. Dep.) 65° 11′ 18″ = .33507
Log. Cosine Init. Course 67° 51′ =9.57638

Cotangent 9.91145 = 50° 48′

50° 48′ × 60′ = 3048 miles Great Circle distance.

GREAT CIRCLE DISTANCE BY COSINE-HAVERSINE FORMULA

This formula is the same as finding the zenith distance in Marcq St. Hilaire method, the zenith distance being the same as the great circle distance.

RULE:

1. With the latitude of departure as the latitude.
   With the latitude of destination as the declination.
   With the difference of longitude between departure and destination as the hour angle.
2. Take out the following logs.:
   Log. Haversine of hour angle.
   Log. Cosine of latitude.
   Log. Cosine of declination.
   Add these three logs. together.
3. Opposite Log. Haversine of sum, read the Nat. Haversine.
4. When latitude and declination are same names, subtract; when contrary names, add.
5. Take out Nat. Haversine of this sum or difference, and add to it the Nat. Haversine already obtained.
6. The Nat. Haversine of this sum will equal the zenith distance.
7. Reduce zenith distance to minutes, and the result will be the great circle distance.

Example:

Lat. Dep.	35° N as Lat.	Long. Dep.	73° W
Lat. Dest.	37° N as Dec.	Long. Dest.	9° W
Diff.	2°	Diff. Long.	64° = H. A. 4h 16m

Log. Haversine H. A. 4h 16m = 9.44842
Log. Cosine Lat. 35° = 9.91336
Log. Cosine Dec. 37° = 9.90235

Log. Haversine 9.26413 = Nat. Hav. .18370
Diff. (Lat. Dec.) 2° = Nat. Hav. .00030

Nat. Hav. .18400 = Z. D.

Z. D. 50° 48′ × 60′ = 3048 Great Circle distance.

TO FIND THE VERTEX OF A GREAT CIRCLE

The vertex of a great circle is the highest (or lowest) point that will be reached when sailing on that particular great circle.

RULE:

1. Add together:
   Log. Cosine of latitude of departure.
   Log. Sine of initial course.
2. Log. Cosine of this sum will equal the latitude of the vertex.
3. Add together:
   Log. Sine of latitude of departure.
   Log. Tangent of initial course.
4. Log. Cotangent of sum will equal the number of degrees and minutes of longitude, the longitude of the vertex is away from the longitude of departure, in a direction towards destination.

Example:

Lat. Dep. 35° N. Initial Course 67° 51′. Long. Dep. 73° W.

Log. Cosine Lat. Dep. 35° = 9.91336
Log. Sine Init. Course 67° 51′ = 9.96670

Cosine 9.88006 = Lat. of Vertex 40° 39′ N
Log. Sine Lat. Dep. 35° = 9.75859
Log. Tang. Init. Course 67° 51′ = .39033

Cotangent 10.14892 = 35° 22′ away from Long. of Dep.

Long. Dep. 73° 0′ W
−35° 22′ E or in direction of destination

Long. Vertex 37° 38′ W

Another method of determining the initial and final great circle course is as follows:

TO FIND INITIAL COURSE BY LOGARITHMS

RULE:

1. Add together:
   Log. Cosine of latitude of destination.
   Log. Sine of difference of longitude.
   Log. Cosecant of zenith distance.
2. Log. Sine of their sum will be the initial course.

Example:

Log. Cosine Lat. Dest. 37° = 9.90235
Log. Sine Diff. Long. 64° = 9.95366
Log. Cosec. Z. D. 50° 48′ = .11073

Log. Sine 9.96674 = Initial Course N 67° 52′ E

TO FIND FINAL COURSE BY LOGARITHMS

RULE:

1. Add together:
   Log. Cosine latitude departure.
   Log. Sine difference of longitude
   Log. Cosecant of zenith distance.
2. Log. Sine of their sum will be the final course.

Example:

Log. Cosine Lat. Dep. 35° = 9.91336
Log. Sine Diff. Long. 64° = 9.95366
Log. Cosec. Z. D. 50° 48′ = .11073

Sine 9.97775 = Final Course S 71° 49′ E

PROBLEM NO. 2

Required initial and second great circle course by azimuth method and computation of logarithms; great circle distance by logarithms and cosine-haversine formula; and the position of the great circle vertex, from a point off the English Channel in Lat. 49° 50′ N, Long. 6° 27′ W, to a point off Abaco L. H. (Hole in the Wall) in Lat. 25° 50′ N, Long. 77° W.

GREAT CIRCLE COURSE BY AZIMUTH METHOD

Lat. Dep. 49° 50′ N as Lat. Long. Dep. 6° 27′ W
Lat. Dest. 25° 50′ N as Dec. Long. Dest. 77° 0′ W

Diff. Long. 70° 33′ = H.A. 4h 42m

Az. Lat. 50° N. Dec. 26° N. H. A. 4h 42m = Initial Course N 86° 30′ W or 273° 30′.

Table 2 at 273° 30′. Dist. 75 = Diff. Lat. 4.5 N. Dep. 74.8. Diff. Long. 116′ W.

Lat. Left	49° 50′ 0″ N	Long. Left	6° 27′ W
Diff. Lat.	4′ 30″ N	Diff. Long.	1° 56′ W
Lat. In	49° 54′ 30″ N	Long. in	8° 23′ W = Dep. for Second Course

Second Course

Lat. Dep.	49° 54′ 30″ N	Long. Dep.	8° 23′ W
		Long. Dest.	77° 0′ W
		Diff. Long.	68° 37′ = H. A. 4h 34m 28s

Az. Lat. 50° N. Dec. 26° N. H. A. 4h 34m = Second Course N 88° W or 272°. This same rule applies to destination.

GREAT CIRCLE COURSE BY COMPUTATION OF LOGARITHMS

Lat. Dep.	49° 50′ N	Long. Dep.	6° 27′ W
Lat. Dest.	25° 50′ N	Long. Dest.	77° 0′ W
		Diff. Long.	70° 33′

Log. Cosine Diff. Long. 70° 33′ = 9.52242
Log. Cotang. Lat. Dest. 25° 50′ = .31503

Tangent	9.83745 = ϕ	34° 31′ 10″
Lat. Dep.		+49° 50′ 0″
Sum		84° 21′ 10″

Log. Cosec. ϕ 34° 31′ 10″ = .24666
Log. Cosine Sum 84° 21′ 10″ = 8.99300
Log. Cotang. Diff. Long. 70° 33′ = 9.54794

Cotangent	8.78760	Init. Course N 86° 29′ 28″ W or 273° 30′

Table 2 at 273° 30′. Dist. 75 = Diff. Lat. 4.5 N. Dep. 74.8. Diff. Long. 116′ W.

Lat. Left	49° 50′ 0″ N	Long. Left	6° 27′ W
Diff. Lat.	4′ 30″ N	Diff. Long.	1° 56′ W
Lat. In.	49° 54′ 30″ N	Long. In.	8° 23′ W = Dep. for Second Course

Second Course

Lat. Dep. 49° 54′ 30″ N Long. Dep. 8° 23′ W
Lat. Dest. 25° 50′ 0″ N Long. Dest. 77° 0′ W

Diff. Long. 68° 37′

Log. Cosine Diff. Long. 68° 37′ = 9.56182
Log. Cotang. Lat. Dest. 25° 50′ = .31503

Tangent 9.87685 = ϕ 36° 59′ 0″
Lat. Dep. +49° 54′ 30″

Sum 86° 53′ 30″

Log. Cosec. ϕ 36° 59′ = .22070
Log. Cosine Sum 86° 53′ 30″ = 8.73419
Log. Cotang. Diff. Long. 68° 37′ = 9.59280

Cotangent 8.54769 = Second Course N 87° 59′ W or 272°

GREAT CIRCLE DISTANCE BY COMPUTATION OF LOGARITHMS

Log. Tangent Sum (ϕ + Lat. Dep.) 84° 21′ 10″ = 1.00488
Log. Cosine Init. Course 86° 29′ 28″ = 8.78679

Cotangent 9.79167 = 58° 14′ 30″

Great Circle Distance = 58° 14′ 30″ × 60 or 3494.5 miles.

GREAT CIRCLE DISTANCE

Lat. Dep. 49° 50′ N as Lat. Long. Dep. 6° 27′ W
Lat. Dest. 25° 50′ N as Dec. Long. Dest. 77° 0′ W

Diff. 24° 0′ Diff. Long. 70° 33′ = H. A. 4h 42m 12s

Log. Hav. H. A. 4h 42m 12s = 9.52311
Log. Cosine Lat. 49° 50′ = 9.80957
Log. Cosine Dec. 25° 50′ = 9.95427

Log. Haversine 9.28695 = Nat. Hav. .19362
Diff. (Lat. Dec.) 24° = Nat. Hav. .04323

Nat. Hav. .23685 = Z. D.

Z. D. 58° 14′ 45″ × 60′ = 3494¾ miles Great Circle distance.

INITIAL COURSE BY LOGARITHMS

Log. Cosine of Lat. Destination 25° 50′ = 9.95427
Log. Sine of Diff. Long. 70° 33′ = 9.97448
Log. Cosec. Zenith Distance 58° 14′ 45″ = .07042

Log. Sine 9.99917 = Init. Course N 86° 27′ W

GREAT CIRCLE VERTEX

Lat. Dep. 49° 50′ N. Init. Course 86° 27′. Long. Dep. 6° 27′ W.

Log. Cosine Lat. Dep. 49° 50′ = 9.80957
Log. Sine Init. Course 86° 27′ = 9.99917

Cosine 9.80874 = Lat. of Vertex 49° 55′ 30″ N

Log. Sine Lat. Dep. 49° 50′ = 9.88319
Log. Tang. Init. Course 86° 27′ = 11.20734

Cotangent 11.09053 = 4° 38″ 30″ away from Long. Dep.

Long. Dep. 6° 27′ 00″ W
+ 4° 38′ 30″ W or in direction of destination

Long. Vertex 11° 5′ 30″ W

PROBLEM NO. 3

Required the initial great circle course by azimuth method and computation of logarithms; the great circle distance; and the position of great circle vertex from Lat. 26° 57′ N Long. 80° 05′ W to Lat. 49° 54′ N Long. 6° 18′ W.?

INITIAL GREAT CIRCLE COURSE BY AZIMUTH METHOD

Lat. Dep. 26° 57′ N as Lat. Long. Dep. 80° 5′ W
Lat. Dest. 49° 54′ N as Decl. Long. Dest. 6° 18′ W

Diff. Long. 73° 47′ = H. A. 4h 55m 8s

Az. Lat. 27° N Decl. 50° N. H. A. 4h 55m = Initial Course N 45° 45′ E

GREAT CIRCLE DISTANCE

Lat. Dep. 26° 57′ N as Lat. Long. Dep. 80° 5′ W
Lat. Dest. 49° 54′ N as Decl. Long. Dest. 6° 18′ W

Diff. 22° 57′ Diff. Long. 73° 47′ = H. A. 4h 55m 8s
Log. Hav. H. A. 4h 55m 8s = 9.55674
Log. Cosine Lat. 26° 57′ = 9.95007
Log. Cosine Dec. 49° 54′ = 9.80897

Log. Haversine 9.31578 = Nat. Hav. .20690

Diff. (Lat. Dec.) 22° 57′ Nat. Hav. .03958

Nat. Haversine .24648 = Zenith Distance

Z. D. 59° 32′ × 60′ = 3572 miles Great Circle Distance.

INITIAL GREAT CIRCLE COURSE BY LOGARITHMS

Log. Cosine of Lat. Destination 49° 54′ = 9.80897
Log. Sine of Diff. Long. 73° 47′ = 9.98237
Log. Cosecant of Zen. Dist. 59° 32′ = .06453

Log. Sine 9.85587 = I. C.
Initial Course N 45° 51′ E

GREAT CIRCLE VERTEX

Lat. Dep. 26° 57′ N. Init. Course 45° 51′. Long. Dep. 80° 5′ W.
Log. Cosine Lat. Dep. 26° 57′ = 9.95007
Log. Sine Init. Course 45° 51′ = 9.85583

Cosine 9.80590 = Lat. Vertex 50° 14′ 20″ N

Log. Sine Lat. Dep. 26° 57′ = 9.65630
Log. Tangent I. C. 45° 51′ = .01289

Cotangent 9.66919 = 64° 58′ 35″ away from Long. Dep.

Long. Dep. 80° 5′ 00″ W
−64° 58′ 35″ E or in direction of destination

Long. Vertex 15° 6′ 25″ W

PROBLEM NO. 4

Required the initial great circle course by azimuth method and computation of logarithms; the great circle distance; and the position of the great circle vertex from Lat. 18° 28′ S Long. 70° 20′ W to Lat. 47° 4′ S Long. 168° 12′ E.?

INITIAL GREAT CIRCLE COURSE BY AZIMUTH METHOD

Lat. Dep. 18° 28′ S as Lat. Long. Dep. 70° 20′ W
Lat. Dest. 47° 4′ S as Decl. Long. Dest. 168° 12′ E

Diff. Long. 121° 28′ = H. A. 8h 5m 52s

Az. Lat. 18° S. Decl. 47° S. H. A. 8h 6m = Initial Course S 35° 49′ W.

GREAT CIRCLE DISTANCE

Lat. Dep. 18° 28′ S as Lat. Long. Dep. 70° 20′ W
Lat. Dest. 47° 4′ S as Decl. Long. Dest. 168° 12′ E

Diff. 28° 36′ Diff. Long. 121° 28′ = H. A. 8h 5m 52s

Log. Hav. H. A. 8h 5m 52s = 9.88139
Log. Cosine Lat. 18° 28′ = 9.97704
Log. Cosine Decl. 47° 4′ = 9.83324

Log. Haversine 9.69167 = Nat. Hav. .49167
Diff. (Lat. Decl.) 28° 36′ = Nat. Hav. .06101

Nat. Haversine .55268 = Zen. Dist.

Z. D. 96° 3′ × 60′ = 5763 miles Great Circle Distance.

INITIAL GREAT CIRCLE COURSE BY LOGARITHMS

Log. Cosine of Lat. Destination 47° 4′ = 9.83324
Log. Sine of Diff. Long. 121° 28′ = 9.93092
Log. Cosecant Zen. Dist. 96° 3′ = .00243

Log. Sine 9.76659 = I. C.

Initial Course S 35° 45′ W

POSITION OF GREAT CIRCLE VERTEX

Lat. Dep. 18° 28′ S. Init. Course 35° 45′ Long. Dep. 70° 20′ W.

Log. Cosine Lat. Dep. 18° 28′ = 9.97704
Log. Sine Init. Course 35° 45′ = 9.76660

Log. Cosine 9.74364 = Lat. of Vertex 56° 21′ S

Log. Sine Lat. Dep. 18° 28′ = 9.50072
Log. Tangent Init. Course 35° 45′ = 9.85727

Log. Cotangent 9.35799 = 77° 9′ 16″ away from Long. Dep.

Long. Dep. 70° 20′ 00″ W
+77° 9′ 16″ W or in direction of destination

Long. Vertex 147° 29′ 16″ W

PROBLEM NO. 5

Required the initial great circle course by azimuth method and computation of logarithms; the great circle distance; and the position of the great circle vertex from Lat. 37° 32′ N. Long. 122° 31′ W to Lat. 35° 27′ N. Long. 139° 39′ E.?

INITIAL GREAT CIRCLE COURSE BY AZIMUTH METHOD

Lat. Dep. 37° 32′ N as Lat. Long. Dep. 122° 31′ W
Lat. Dest. 35° 27′ N as Decl. Long. Dest. 139° 39′ E

Diff. Long. 97° 50′ = H. A. 6h 31m 20s

Az. Lat. 37½° N. Decl. 35½° N. H. A. 6h 31m = Initial Course N 56° 49′ W

GREAT CIRCLE DISTANCE

Lat. Dep. 37° 32′ N as Lat. Long. Dep. 122° 31′ W
Lat. Dest. 35° 27′ N as Decl. Long. Dest. 139° 39′ E

Diff. 2° 5′ Diff. Long. 97° 50′ = H. A. 6h 31m 20s

Log. Hav. H. A. 6h 31m 20s = 9.75446
Log. Cosine Lat. 37° 32′ = 9.89927
Log. Cosine Decl. 35° 27′ = 9.91096

Log. Haversine 9.56469 = Nat. Hav. .36701
Diff. (Lat. Decl.) 2° 5′ = Nat. Hav. .00033

Nat. Haversine .36734 = Z. D.

Zen. Distance 74° 36′ 45″ × 60′ = 4476¾ miles Great Circle Distance.

INITIAL GREAT CIRCLE COURSE BY LOGARITHMS

Log. Cosine of Lat. Destination 35° 27′ = 9.91096
Log. Sine of Diff. Long. 97° 50′ = 9.99593
Log. Cosecant of Zen. Dist. 74° 36′ 45″ = .01585

Log. Sine 9.92274 = I. C.

Initial Course N 56° 50′ W.

POSITION OF GREAT CIRCLE VERTEX

Lat. Dep. 37° 32′ N. Init. Course 56° 50′ Long. Dep. 122° 31′ W.

Log. Cosine of Lat. Departure 37° 32′ = 9.89927
Log. Sine Init. Course 56° 50′ = 9.92277

Log. Cosine 9.82204 = Lat. Vertex 48° 24′ 30″ N

Log. Sine of Lat. Departure 37° 32′ = 9.78478
Log. Tangent of Init. Course 56° 50′ = .18472

Log. Cotangent 9.96950 = 47° 0′ 30″ away from Long. Dep.

Long. Departure 122° 31′ 00″ W
+ 47° 0′ 30″ W or in direction of destination.

Long. Vertex 169° 31′ 30″ W

PROBLEM NO. 6

Required the initial great circle course by azimuth method and computation of logarithms; the great circle distance; and the position of the great circle vertex from Lat. 22° 55′ S. Long. 43° 9′ W. to Lat. 34° 21′ S. Long. 18° 30′ E.?

INITIAL GREAT CIRCLE COURSE BY AZIMUTH METHOD

Lat. Dep. 22° 55′ S as Lat. Long. Dep. 43° 9′ W
Lat. Dest. 34° 21′ S as Decl. Long. Dest. 18° 30′ E

Diff. Long. 61° 39′ = H. A. 4h 6m 36s

Az. Lat. 23° S. Decl. 34° S. H. A. 4h 7m = Initial Course S 63° 15′ E.

GREAT CIRCLE DISTANCE

Lat. Dep. 22° 55′ S as Lat. Long. Dep. 43° 9′ W
Lat. Dest. 34° 21′ S as Decl. Long. Dest. 18° 30′ E

Diff. 11° 26′ Diff. Long. 61° 39′ = H. A. 4h 6m 36s

Log. Haversine H. A. 4h 6m 36s = 9.41925
Log. Cosine Lat. 22° 55′ = 9.96429
Log. Cosine Decl. 34° 21′ = 9.91677

Log. Haversine 9.30031 = Nat. Hav. .19967
Diff. (Lat. Decl.) 11° 26′ = Nat. Hav. .00992

Nat. Haversine .20959 = Z. D.

Zen. Distance 54° 29′ 30″ × 60′ = 3269½ miles Great Circle Distance.

INITIAL GREAT CIRCLE COURSE BY LOGARITHMS

Log. Cosine of Lat. Destination 34° 21′ = 9.91677
Log. Sine of Diff. Long. 61° 39′ = 9.94451
Log. Cosecant of Z. D. 54° 29′ 30″ = .08935

Log. Sine 9.95063 = I. C.

Initial Course S 63° 12′ E.

POSITION OF GREAT CIRCLE VERTEX

Lat. Dep. 22° 55′ S. Init. Course 63° 12′. Long. Dep. 43° 9′ W.

Log. Cosine of Lat. Departure 22° 55′ = 9.96429
Log. Sine Init. Course 63° 12′ = 9.95065

Log. Cosine 9.91494 = Lat. Vertex 34° 42′ S

Log. Sine of Lat. Departure 22° 55′ = 9.59039
Log. Tangent Init. Course 63° 12′ = .29659

Log. Cotangent 9.88698 = 52° 22′ away from Long. Dep.

Long. Departure 43° 9′ W
−52° 22′ E or in direction of destination.

Long. Vertex 9° 13′ E

CHAPTER XIII

COMPOSITE SAILING

When it is found impracticable or unadvisable to follow the great circle track between any two points to its highest latitude on account of dangerous waters or obstructions, such as ice, etc., a limiting parallel of latitude may be chosen. A great circle is then sailed from departure to a point on the limiting parallel; a course is then steered on the limiting parallel; and another great circle is sailed from a point on the limiting parallel to point of destination.

In plain words, the problem is: "I wish to go not higher on my course than a certain parallel of latitude. Where shall I enter this parallel, and where shall I leave it?"

For example: A vessel in Lat. 25° S, Long. 30° W, is bound to a point in Lat. 38° 40′ S, Long. 144° 15′ E, and it is decided not to go south of the parallel of 54° S.

Required: The longitude of entering parallel and the longitude at which it should be left?

TO FIND LONGITUDE AT WHICH PARALLEL OF LATITUDE IS ENTERED

RULE:

1. Add together:
   Log. Tangent of latitude of departure.
   Log. Cotangent of latitude of limiting parallel.
2. Log. Cosine of sum equals the number of degrees and minutes of longitude to be applied to longitude of departure, in a direction towards destination. This will give the longitude of entering parallel.

Example:

Log. Tangent Lat. Dep. 25° = 9.66867
Log. Cotangent Lat. Lim. Par. 54° = 9.86126

Cosine 9.52993 = 70° 11′ 47″ of longitude to be applied to longitude of departure

Long. Dep. 30° 0′ 0″ W
70° 11′ 47″ E or in direction towards destination

40° 11′ 47″ E longitude of entering parallel

TO FIND LONGITUDE AT WHICH PARALLEL IS LEFT

RULE:

1. Add together:
   Log. Tangent of latitude of destination.
   Log. Cotangent of latitude of limiting parallel.
2. Log. Cosine of sum equals the number of degrees and minutes of longitude to be applied to longitude of destination, in a direction towards the point of departure.

This will give the longitude at which parallel should be left.

Example:

Log. Tangent Lat. Dest. 38° 40′ = 9.90320
Log. Cotangent Lat. Lim. Par. 54° = 9.86126

Cosine 9.76446 = 54° 27′ 6″ of longitude to be applied to longitude of destination

Long. Destination 144° 15′ 0″ E
54° 27′ 6″ W or in direction towards departure

89° 47′ 54″ E long. at which parallel should be left

CHAPTER XIV

LATITUDE BY MERIDIAN ALTITUDE OF SUN

The latitude by the sun is found most easily by a noon sight, when the sun is on the meridian or the highest point reached by the sun on that day.

When the sun crosses the meridian it is either directly overhead or due north or south. It is then exactly 12h 0m 0s local apparent time (L. A. T.).

A chronometer always shows Greenwich time, and if we could read the chronometer when the sun was exactly at its highest point and was about to descend, we could use that time to look up the declination in the nautical almanac.

As at this time the sun's motion is nearly horizontal—i.e., its rise is very slow, it is very difficult to tell when it has ceased to ascend and is starting to descend.

If the longitude is known, the Greenwich Apparent Time (G. A. T.) may be found; for longitude expressed in hours, minutes and seconds is the difference between local and Greenwich time.

If in west longitude the apparent time at Greenwich will be past noon; therefore, add the longitude in time to 12 hours, and the answer will be the G. A. T. of the same day as the ship.

If in east longitude the apparent time at Greenwich will be before noon; therefore, subtract the longitude in time from 12 hours, and the answer will be the G. A. T. of the same day as the ship.

In the nautical almanac, the equation of time is given with + or − signs to show whether it is to be added to or subtracted from the Greenwich Civil Time (G. C. T.) to get the G. A. T.

Since the G. A. T. is known and the G. C. T. is desired, the equation of time is applied the opposite way to that shown by the signs in the nautical almanac.

It is necessary to know the G. C. T. when the sight was taken, for the declination at that instant must be known, and the declination is given in the nautical almanac for G. C. T. and not for G. A. T. or L. A. T.

The declination of the sun is the distance north or south of the equator. The sign + in the almanac means north, the sign − south. The declination is given for each day and on the even hour of that day.

To find the declination for any given time, look up in the almanac the declination for the even hour preceding. This is corrected by adding or subtracting the change in the intervening minutes. The hourly difference (H. D.) is found printed in the almanac at the end of each day. This is multiplied by the fractional part of an hour to get the correction. If the declination is decreasing this is subtracted, if increasing it is added.

The altitude is measured by the sextant.

When the sun is on the meridian, it is either due north, directly overhead, or due south of the observer.

The index error (I. E.) is the error of the sextant used for the observation. When it is "off the scale" it is added; when "on scale" it is subtracted.

The semi-diameter (S. D.) is half the diameter of the sun, or the distance from the bottom or top of the sun to the center. In lower limb (L. L.) sights, or sights taken on the lower edge, the S. D. is added. In upper limb (U. L.) sights it is subtracted. It is given in the nautical almanac. The nearest date is used and the nearest .01 of a minute.

The dip correction is the correction for the height of the eye of the observer above sea level. It is always subtracted and is found in Table 14 (Bowditch).

Refraction is the change of direction of a ray of light in passing through the atmosphere.

Parallax is the error caused by taking altitude from the surface of the earth while the calculations are made on the assumption that the observer is at the center of the earth.

The corrections for refraction and parallax (R. & P.) are combined in Table 20B and are always subtracted.

After making these corrections to the observed meridian altitude, the answer is the true altitude.

The point in the sky directly over the observer's head is the zenith. It is 90° from the horizon in all directions.

Subtracting the altitude from 90° gives the zenith distance (Z. D.) or distance from the sun to the zenith. It always has the opposite name to the sun's bearing.

Under zenith distance put down the true declination.

If both are the same name add; the sum is the latitude, named the same.

If different names, subtract the lesser from the greater; the difference is the latitude, named the same as the greater.

PROBLEM NO. 1

Jan. 30, 1936. Obs. Mer. Alt. Sun's L. L. 44° 18′ S. Dip 36 ft. Long. 91° W. Required Lat.?

Longitude in time 6h 4m		L. A. T. 30d	12h 0m 0s
Obs. Alt.	44° 18′ 00″	Long.	+ 6h 4m 0s
S. D.	+ 16′ 16″		
		G. A. T.	18h 4m 0s
	44° 34′ 16″	Eq. Time	+ 13m 20s
Dip	− 5′ 53″		
		G. C. T. 30d	18h 17m 20s or
	44° 28′ 23″	30d	18.3h
R. & P.	− 53″		
True Alt. (h)	44° 27′ 30″ S	Dec. for 30d 18h	17° 49′.7
	90° 0′ 0″	Corr. for .3h	− .2
Z. D.	45° 32′ 30″ N	Dec. 30d 18.3h	17° 49′.5 S
T. Decl.	17° 49′ 30″ S	H. D. = 0.7′ Dec. decreasing	
		Corr. for .3h × 0.7′ = .21′	
Lat.	27° 43′ 00″ N		

PROBLEM NO. 2

Feb. 1, 1936. Obs. Mer. Alt. Sun's L. L. 78° 5′ 5″ S. Dip 12 ft. Long. 78° 14′ E. Required Lat.?

Long. in time 5h 12m 56s		L. A. T. 1d	12h 0m 0s
Obs. Alt.	78° 5′ 5″	Long.	− 5h 12m 56s
S. D.	+ 16′ 16″		
		G. A. T.	6h 47m 4s
	78° 21′ 21″	Eq. T.	+ 13m 35s
Dip	− 3′ 24″		
		G. C. T. 1d	7h 0m 39s
	78° 17′ 57″		
R. & P.	− 10″		
		Dec. for 1d 6h	17° 25′.0
True Alt.	78° 17′ 47″ S	Corr. for 1h	− .7
	90° 00′ 00″		
		Dec. for 1d 7h	17° 24′.3 S
Z. D.	11° 42′ 13″ N	H. D. = 0′.7 Decl. decreasing	
T. Dec.	17° 24′ 18″ S	Corr. for 1h = 1 × .7 = .7	
Lat.	5° 42′ 5″ S		

PROBLEM NO. 3

March 20, 1936. Obs. Mer. Alt. Sun's L. L. 89° 37′ N. Index Error +4′ 27″. Dip 18 ft. Long. 111° E. Required Lat.?

Long. in time 7h 24m	
Obs. Alt.	89° 37′ 0″
I. E.	+ 4′ 27″
	89° 41′ 27″
S. D.	+ 16′ 5″
	89° 57′ 32″
Dip	− 4′ 9″
True Alt.	89° 53′ 23″ N
	90° 00′ 00″
Z. D.	6′ 37″ S
T. D.	14′ 6″ S
Lat.	0° 20′ 43″ S

L. A. T. 20d	12h 0m 0s
Long.	− 7h 24m 0s
G. A. T.	4h 36m 0s
Eq. Time	+ 7m 41s
G. C. T. 20d	4h 43m 41s or
20d	4.7h
Dec. for 20d 4h	0° 14′.8
Corr. for .7h	− .7
Dec. for 20d 4.7h	0° 14′.1 S

H. D. = 1′.0 Dec. decreasing
Corr. for .7h = 1′ × .7 = .7

PROBLEM NO. 4

March 10, 1936. Obs. Mer. Alt. Sun's L. L. 59° 59′ 50″ S. Index Error +50″. Dip 15 ft. Long. 102° 41′ W. Required Lat.?

Long. in time 6h 50m 44s	
Obs. Alt.	59° 59′ 50″
I. E.	+ 50″
	60° 0′ 40″
S. D.	+ 16′ 8″
	60° 16′ 48″
Dip	− 3′ 48″
	60° 13′ 0″
R. & P.	− 30″
True Alt.	60° 12′ 30″ S
	90° 00′ 00″
Z. D.	29° 47′ 30″ N
T. D.	3° 56′ 42″ S
Lat.	25° 50′ 48″ N

L. A. T. 10d	12h 0m 0s
Long.	+ 6h 50m 44s
G. A. T.	18h 50m 44s
Eq. Time	+ 10m 20s
G. C. T. 10d	19h 1m 4s
Dec. for 10d 18h	3° 57′.7
Corr. for 1h	1′.0
Dec. for 10d 19h	3° 56′.7 S

H. D. = 1′.0 Dec. decreasing
Corr. for 1h = 1′ × 1h = 1′

PROBLEM NO. 5

Jan. 31, 1936. Obs. Mer. Alt. Sun's L. L. 46° 56′ S. Dip 36 ft. Long. 94° W. Required Lat.?

Long. in time	6h 16m
Obs. Alt.	46° 56′ 0″
S. D.	+ 16′ 16″
	47° 12′ 16″
Dip	− 5′ 53″
	47° 6′ 23″
R. & P.	− 48″
True Alt.	47° 5′ 35″ S
	90° 00′ 00″
Z. D.	42° 54′ 25″ N
T. D.	17° 33′ 0″ S
Lat.	25° 21′ 25″ N

L. A. T. 31d	12h 0m 0s
Long.	+ 6h 16m 0s
G. A. T.	18h 16m 0s
Eq. Time	+ 13m 30s
G. C. T. 31d	18h 29m 30s or
31d	18.5h
Dec. for 31d 18h	17° 33′.3
Corr. for .5h	− .3
Dec. for 31d 18.5h	17° 33′.0 S

H. D. = .7 Dec. decreasing
Corr. for .5h = .7 × .5 = .35

PROBLEM NO. 6

March 21, 1936. Obs. Mer. Alt. Sun's L. L. 57° 21′ S. Dip 38 ft. Long. 77° 26′ W. Required Lat.?

Long. in time	5h 9m 44s
Obs. Alt.	57° 21′ 00″
S. D.	+ 16′ 5″
	57° 37′ 5″
Dip	− 6′ 2″
	57° 31′ 3″
R. & P.	− 32″
True Alt.	57° 30′ 31″ S
	90° 00′ 00″
Z. D.	32° 29′ 29″ N
T. D.	22′ 6″ N
Lat.	32° 51′ 35″ N

L. A. T. 21d	12h 0m 0s
Long.	+ 5h 9m 44s
G. A. T.	17h 9m 44s
Eq. Time	+ 7m 14s
G. C. T. 21d	17h 16m 58s or
21d	17.3h
Dec. for 21d 16h	0° 20′.8
Corr. for 1.3h	+ 1′.3
Dec. for 21d 17.3h	0° 22′.1 N

H. D. = 1′.0 Dec. increasing
Corr. for 1.3h = 1.3 × 1′ = 1′.3

PROBLEM NO. 7

Sept. 3, 1936. Obs. Mer. Alt. Sun's L. L. 49° 2′ 15″ S. Dip 28 ft. Long. 118° 15′ E. Required Lat.?

Long. in time 7h 53m	
Obs. Alt.	49° 2′ 15″
S. D.	+ 15′ 54″
	49° 18′ 9″
Dip	− 5′ 11″
	49° 12′ 58″
R. & P.	− 45″
True Alt.	49° 12′ 13″ S
	90° 0′ 0″
Z. D.	40° 47′ 47″ N
T. D.	7° 38′ 48″ N
Lat.	48° 26′ 35″ N

L. A. T. 3d	12h 0m 0s
Long.	− 7h 53m 0s
G. A. T.	4h 7m 0s
Eq. Time	− 36s
G. C. T. 3d	4h 6m 24s or
3d	4.1h
Dec. for 3d 4h	7° 38′.9
Corr. for .1h	− .1
Dec. for 3d 4.1h	7° 38′.8 N

H. D. = 0′.9 Dec. decreasing
Corr. for .1h = .1 × .9 = .09

PROBLEM NO. 8

Aug. 8, 1936. Obs. Mer. Alt. Sun's L. L. 38° 16′ N. Dip 27 ft. Long. 3° 15′ W. Required Lat.?

Long. in time 0h 13m	
Obs. Alt.	38° 16′ 0″
S. D.	+ 15′ 48″
	38° 31′ 48″
Dip	− 5′ 6″
	38° 26′ 42″
R. & P.	− 1′ 7″
True Alt.	38° 25′ 35″ N
	90° 0′ 0″
Z. D.	51° 34′ 25″ S
T. D.	16° 7′ 24″ N
Lat.	35° 27′ 1″ S

L. A. T. 8d	12h 0m 0s
Long.	+ 13m 0s
G. A. T.	12h 13m 0s
Eq. Time	+ 5m 30s
G. C. T. 8d	12h 18m 30s or
8d	12.3h
Dec. for 8d 12h	16° 7′.6
Corr. for .3h	− .2
Dec. for 8d 12.3h	16° 7′.4 N

H. D. = 0′.7 Dec. decreasing
Corr. for .3h = .3 × .7 = .21′

PROBLEM NO. 9

July 4, 1936. Obs. Mer. Alt. Sun's L. L. 70° 15′ S. Dip 4 ft. Long. 97° 12′ W. Required Lat.?

Long. in time	6h 28m 48s
Obs. Alt.	70° 15′ 0″
S. D.	+ 15′ 46″
	70° 30′ 46″
Dip	− 4′ 48″
	70° 25′ 58″
R. & P.	− 18″
True Alt.	70° 25′ 40″ S
	90° 0′ 0″
Z. D.	19° 34′ 20″ N
T. D.	22° 51′ 18″ N
Lat.	42° 25′ 38″ N

L. A. T. 4d	12h 0m 0s
Long.	+ 6h 28m 48s
G. A. T.	18h 28m 48s
Eq. Time	+ 4m 15s
G. C. T. 4d	18h 33m 3s or
4d	18.6h
Dec. for 4d 18h	22° 51′.4
Corr. for .6h	− .1
Dec. for 4d 18.6h	22° 51′.3 N

H. D. = 0′.2 Dec. decreasing
Corr. for .6h = .6 × .2 = .12′

PROBLEM NO. 10

April 18, 1936. Obs. Mer. Alt. Sun's L. L. 41° 2′ S. Dip 22 ft. Long. 97° 15′ E. Required Lat.?

Long. in time	6h 29m
Obs. Alt.	41° 2′ 0″
S. D.	+ 15′ 57″
	41° 17′ 57″
Dip	− 4′ 36″
	41° 13′ 21″
R. & P.	− 59″
True Alt.	41° 12′ 22″ S
	90° 0′ 0″
Z. D.	48° 47′ 38″ N
T. D.	10° 46′ 12″ N
Lat.	59° 33′ 50″ N

L. A. T. 18d	12h 0m 0s
Long.	− 6h 29m
G. A. T.	5h 31m 0s
Eq. Time	− 35s
G. C. T. 18d	5h 30m 25s or
18d	5.6h
Dec. for 18d 4h	10° 44′.8
Corr. for 1.6h	+ 1′.4
Dec. for 18d 5.6h	10° 46′.2 N

H. D. = 0′.9 Dec. increasing
Corr. for 1.6h = 1.6 × .9 = 1.44′

PROBLEM NO. 11

March 11, 1936. Obs. Mer. Alt. Sun's L. L. 81° 16′ N. Index Error −3′ 20″. Dip 28 ft. Long. 19° 16′ E. Required Lat.?

Long. in time 1h 17m 4s			
Obs. Alt.	81° 16′ 0″		
I. E.	− 3′ 20″		
	81° 12′ 40″		
S. D.	+ 16′ 8″		
	81° 28′ 48″		
Dip	− 5′ 11″		
	81° 23′ 37″		
R. & P.	− 7″		
True Alt.	81° 23′ 30″ N		
	90° 0′ 0″		
Z. D.	8° 36′ 30″ S		
T. D.	3° 41′ 6″ S		
Lat.	12° 17′ 36″ S		

L. A. T. 11d	12h 0m 0s
Long.	− 1h 17m 4s
G. A. T.	10h 42m 56s
Eq. Time	+ 10m 10s
G. C. T. 11d	10h 53m 6s or
11d	10.9h
Dec. for 11d 10h	3° 42′.0
Corr. for .9h	− .9
Dec. for 11d 10.9h	3° 41′.1 S

H. D. = 1′.0 Dec. decreasing
Corr. for .9h = .9 × 1′ = .9

PROBLEM NO. 12

Oct. 23, 1936. Obs. Mer. Alt. Sun's L. L. 37° 21′ S. Index Error +9′ 10″. Dip 16 ft. Long. 86° 15′ W. Required Lat.?

Long. in time 5h 45m			
Obs. Alt.	37° 21′ 0″		
I. E.	+ 9′ 10″		
	37° 30′ 10″		
S. D.	+ 16′ 6″		
	37° 46′ 16″		
Dip	− 3′ 55″		
	37° 42′ 21″		
R. & P.	− 1′ 8″		
True Alt.	37° 41′ 13″ S		
	90° 0′ 0″		
Z. D.	52° 18′ 47″ N		
T. D.	11° 31′ 18″ S		
Lat.	40° 47′ 29″ N		

L. A. T. 23d	12h 0m 0s
Long.	+ 5h 45m 0s
G. A. T.	17h 45m 0s
Eq. Time	− 15m 39s
G. C. T. 23d	17h 29m 21s or
23d	17.5h
Dec. for 23d 16h	11° 30′.0
Corr. for 1.5h	+ 1′.3
Dec. for 23d 17.5h	11° 31′.3 S

H. D. = 0′.9 Dec. increasing
Corr. for 1.5h = 1.5 × .9 = 1.35′

PROBLEM NO. 13

Oct. 11, 1936. Obs. Mer. Alt. Sun's L. L. 26° 53′ 10″ S. Index Error −2′ 40″. Dip 17 ft. Long. 18° 2′ W. Required Lat.?

Long. in time 1h 12m 8s	
Obs. Alt.	26° 53′ 10″
I. E.	− 2′ 40″
	26° 50′ 30″
S. D.	+ 16′ 3″
	27° 6′ 33″
Dip	− 4′ 2″
	27° 2′ 31″
R. & P.	− 1′ 46″
True Alt.	27° 0′ 45″ S
	90° 0′ 0″
Z. D.	62° 59′ 15″ N
T. D.	7° 4′ 18″ S
Lat.	55° 54′ 57″ N

L. A. T. 11d	12h 0m 0s
Long.	+ 1h 12m 8s
G. A. T.	13h 12m 8s
Eq. Time	− 13m 15s
G. C. T. 11d	12h 58m 53s or
11d	13h
Dec. for 11d 12h	7° 3′.4
Corr. for 1h	+ .9
Dec. for 11d 13h	7° 4′.3 S

H. D. = 0′.9 Dec. increasing
Corr. for 1h = 1 × .9 = .9

PROBLEM NO. 14

April 3, 1936. Obs. Mer. Alt. Sun's L. L. 60° 22′ S. Dip 21 ft. Long. 20° 59′ E. Required Lat.?

Long. in time 1 h 23m 56s	
Obs. Alt.	60° 22′ 0″
S. D.	+ 16′ 1″
	60° 38′ 1″
Dip	− 4′ 29″
	60° 33′ 32″
R. & P.	− 29″
True Alt.	60° 33′ 3″ S
	90° 0′ 0″
Z. D.	29° 26′ 57″ N
T. D.	5° 20′ 0″ N
Lat.	34° 46′ 57″ N

L. A. T. 3d	12h 0m 0s
Long.	− 1h 23m 56s
G. A. T.	10h 36m 4s
Eq. Time	+ 3m 22s
G. C. T. 3d	10h 39m 26s or
3d	10.7h
Dec. for 3d 10h	5° 19′.3
Corr. for .7h	+ .7
Dec. for 3d 10.7h	5° 20′.0 N

H. D. 1′.0 Dec. increasing
Corr. for .7h = .7 × 1′ = .7

PROBLEM NO. 15

Aug. 30, 1936. Obs. Mer. Alt. Sun's L. L. 57° 18′ 30″ N. Index Error +45″. Dip 18 ft. Long. 129° 15′ W. Required Lat.?

Long. in time 8h 37m		L. A. T. 30d	12h 0m 0s
Obs. Alt.	57° 18′ 30″	Long.	+ 8h 37m 0s
I. E.	+ 45″		
	57° 19′ 15″	G. A. T.	20h 37m 0s
S. D.	+ 15′ 53″	Eq. Time	+ 27s
	57° 35′ 8″	G. C. T. 30d	20h 37m 27s or
Dip	− 4′ 9″	30d	20.6h
	57° 30′ 59″	Dec. for 30d 20h	8° 51′.5
R. & P.	− 32″	Corr. for .6h	− .5
True Alt.	57° 30′ 27″ N	Dec. for 30d 20.6h	8° 51′.0 N
	90° 0′ 0″	H. D. = 0′.9 Dec. decreasing	
Z. D.	32° 29′ 33″ S	Corr. for .6h = .6 × .9 = .54′	
T. D.	8° 51′ 0″ N		
Lat.	23° 38′ 33″ S		

PROBLEM NO. 16

Dec. 3, 1936. Obs. Mer. Alt. Sun's L. L. 64° 45′ 15″ N. Index Error −1′ 10″. Dip 20 ft. Long. 63° 18′ E. Required Lat.?

Long. in time 4h 13m 12s		L. A. T. 3d	12h 0m 0s
Obs. Alt.	64° 45′ 15″	Long.	− 4h 13m 12s
I. E.	− 1′ 10″		
	64° 44′ 5″	G. A. T.	7h 46m 48s
S. D.	+ 16′ 15″	Eq. Time	− 10m 12s
	65° 0′ 20″	G. C. T.	7h 36m 36s or
Dip	− 4′ 23″	3d	7.6h
	64° 55′ 57″	Dec. for 3d 6h	22° 5′.2
R. & P.	− 23″	Corr. for 1.6h	+ .6
True Alt.	64° 55′ 34″ N	Dec. for 3d 7.6h	22° 5′.8 S
	90° 0′ 0″	H. D. = 0′.4 Dec. increasing	
Z. D.	25° 4′ 26″ S	Corr. for 1.6 × .4 = .64′	
T. D.	22° 5′ 48″ S		
Lat.	47° 10′ 14″ S		

PROBLEM NO. 17

March 20, 1936. Obs. Mer. Alt. Sun's L. L. 89° 42′ 40″ N. Index Error +2′ 20″. Dip 20 ft. Long. 101° 30′ W. Required Lat.?

Long. in time 6h 46m		
Obs. Alt.		89° 42′ 40″
I. E.	+	2′ 20″
		89° 45′ 0″
S. D.	+	16′ 5″
		90° 1′ 5″
Dip	−	4′ 23″
True Alt.		89° 56′ 42″ N
		90° 0′ 0″
Z. D.		3′ 18″ S
T. D.		0′ 6″ S
Lat.		0° 3′ 24″ S

L. A. T. 20d		12h 0m 0s
Long.	+	6h 46m
G. A. T.		18h 46m 0s
Eq. Time	+	7m 30s
G. C. T. 20d		18h 53m 30s or 18.9h
Dec. for 20d 18h		0° 1′.0
Corr. for .9h	−	.9
Dec. for 20d 18.9h		0° 0′.1 S

H. D. = 1′.0 Dec. decreasing
Corr. for .9h = .9 × 1′ = .9

PROBLEM NO. 18

Nov. 23, 1936. Obs. Mer. Alt. Sun's L. L. 58° 49′ S. Index Error +7′ 48″. Dip 29 ft. Long. 162° 47′ E. Required Lat.?

Long. 10h 51m 8s.		
Obs. Alt.		58° 49′ 0″
I. E.	+	7′ 48″
		58° 56′ 48″
S. D.	+	16′ 13″
		59° 13′ 1″
Dip	−	5′ 17″
		59° 7′ 44″
R. & P.	−	31″
True Alt.		59° 7′ 13″ S
		90° 0′ 0″
Z. D.		30° 52′ 47″ N
T. D.		20° 16′ 36″ S
Lat.		10° 36′ 11″ N

L. A. T. 23d		12h 0m 0s
Long.	−	10h 51m 8s
G. A. T.		1h 8m 52s
Eq. Time	−	13m 39s
G. C. T. 23d		0h 55m 13s or
23d		.9h
Dec. for 23d 0h		20° 16′.1
Corr. for .9h	+	.5
Dec. for 23d 0.9h		20° 16′.6 S

H. D. = 0′.5 Dec. increasing
Corr. for .9h = .9 × .5 = .45′

CHAPTER XV

LATITUDE CONSTANT

In practice, probable position at noon is figured in advance by dead reckoning. The officer can then know at what time by the chronometer noon will occur.

Very commonly, sights are worked up in detail before noon and an expression obtained which only requires the introduction of the observed altitude to obtain the latitude at once.

Performing this work in advance enables the officer to have his position immediately after noon. Knowing approximate altitude before taking the sight is also of great value on a cloudy day.

RULE:

1. Find G. C. T. and declination as in previous latitude observations.
2. If D. R. Lat. and Decl. are same names, the difference between them is the Z. D. If opposite names, the sum is the Z. D.
3. The Z. D. is the opposite name to sun's bearing.
4. Subtract Z. D. from 90°, the difference is the Approximate Altitude.
5. Take out the altitude corrections—i.e., I. E. (if any), S. D., Dip, R. & P., and add together in separate columns the + and − corrections, subtract less from greater, and find total altitude correction.
6. If declination and latitude are opposite names, or if same names with declination greater, apply altitude correction to declination, and subtract from 90° to get the constant.
7. If same names, but latitude greater than declination, apply altitude correction with opposite sign to declination—i.e., add if −, subtract if +. This result added to 90° will give the constant.
8. Subtract the Obs. Mer. Alt. from the constant and the result will be the latitude.

PROBLEM NO. 1

July 5, 1936. Probable noon position Lat. 41° 7′ N., Long. 143° 17′ E. Index Error +1′ 30″. Dip 36 ft.

Long. in time 9h 33m 8s		
Prob. Lat.		41° 07′ 0″ N
Dec.		22° 49′ 30″ N
Approx. Z. D.		18° 17′ 30″ N
		90° 0′ 0″
Approx. Alt.		71° 42′ 30″ S
R. & P.	−	16″
Dip	−	5′ 53″
	−	6′ 9″
S. D.	+	15′ 46″
	+	9′ 37″
I. E.	+	1′ 30″
Total Alt. Corr.	+	11′ 7″ +

L. A. T. 5d	12h 0m 0s
Long.	− 9h 33m 8s
G. A. T.	2h 26m 52s
Eq. Time	+ 4m 19s
G. C. T. 5d	2h 31m 11s
Dec. for 5d 2h	22° 49′.6
Corr. for .5h	− .1
Dec. for 5d 2.5h	22° 49′.5 N
(Dec. and lat. same name, lat. greater)	
Dec.	22° 49′ 30″ N
Corr.	− 11′ 7″
	22° 38′ 23″
	+90° 0′ 0″
Const.	112° 38′ 23″ N

Officer will prepare to take sight when chronometer reads 2h 31m.

The Mer. Alt. Sun's L. L. is now measured and found to be 71° 41′ 10″ S.

Const. 112° 38′ 23″ N − Obs. Alt. 71° 41′ 10″ S = Lat. 40° 57′ 13″ N.

PROBLEM NO. 2

Jan. 30, 1936. Probable noon position Lat. 43° 17′ N., Long. 61° 11′ W. Index Error −1′ 20″. Dip 36 ft.

Long. in time 4h 4m 44s		
Prob. Lat.		43° 17′ 0″ N
Dec.		17° 50′ 54″ S
Approx. Z. D.		61° 7′ 54″ N
		90° 0′ 0″
Approx. Alt.		28° 52′ 6″ S
R. & P.	−	1′ 37″
Dip	−	5′ 53″
I. E.	−	1′ 20″
	−	8′ 50″
S. D.	+	16′ 16″
Alt. Corr.	+	7′ 26″

L. A. T. 30d	12h 0m 0s
Long.	+ 4h 4m 44s
G. A. T.	16h 4m 44s
Eq. Time	+ 13m 20s
G. C. T. 30d	16h 18m 4s or
30d	16.3h
Dec. for 30d 16h	17° 51′.1
Corr. for .3h	− .2
Dec. for 30d 16.3h	17° 50′.9 S
(Dec. and lat. opposite names)	
Dec.	17° 50′ 54″ S
Alt. Corr.	+ 7′ 26″
	17° 58′ 20″
	−90° 0′ 0″
Const.	72° 1′ 40″ N

Officer takes sight at 4.18 P. M. by chronometer.

The Mer. Alt. Sun's L. L. is found to be 29° 0′ bearing S.

Const. 72° 1′ 40″ N − Obs. Alt. 29° 0′ S = Lat. 43° 1′ 40″ N.

PROBLEM NO. 3

Aug. 8, 1936. Probable noon position Lat. 31° 16′ 10″ S., Long. 22° 10′ E. Index Error +30″. Dip 36 ft.

Long. in time 1h 28m 40s		
Prob. Lat.		31° 16′ 10″ S
Dec.		16° 8′ 36″ N
Approx. Z. D.		47° 24′ 46″ S
		90° 0′ 0″
Approx. Alt.		42° 35′ 14″ N
R. & P.	−	57″
Dip	−	5′ 53″
	−	6′ 50″
S. D.	+	15′ 48″
	+	8′ 58″
I. E.	+	30″
Alt. Corr.	+	9′ 28″

L. A. T. 8d		12h 0m 0s
Long.	−	1h 28m 40s
G. A. T.		10h 31m 20s
Eq. Time	+	5m 31s
G. C. T. 8d		10h 36m 51s or
8d		10.6h
Dec. for 8d 10h		16° 9′.0
Corr. for .6h	−	.4
Dec. for 8d 10.6h		16° 8′.6 N
(Dec. and lat. opposite names)		
Dec.		16° 8′ 36″ N
Alt. Corr.	+	9′ 28″
		16° 18′ 4″
		−90° 0′ 0″
Const.		73° 41′ 56″ S

Sun will cross the meridian when chronometer reads 10h 36m 51s A.M.
The Mer. Alt. Sun's L. L. is found to be 42° 50′ bearing North.
Const. 73° 41′ 56″ S − Obs. Alt. 42° 50′ N = Lat. 30° 51′ 56″ S.

PROBLEM NO. 4

Dec. 15, 1936. Probable noon position Lat. 10° 12′ S., Long. 60° W.
Dip 36 ft.

Long. in time 4h		
Prob. Lat.		10° 12′ 0″ S
Dec.		23° 17′ 18″ S
Approx. Z. D.		13° 5′ 18″ N
		90° 0′ 0″
Approx. Alt.		76° 54′ 42″ S
R. & P.	−	12″
Dip	−	5′ 53″
	−	6′ 5″
S. D.	+	16′ 17″
Alt. Corr.	+	10′ 12″

L. A. T. 15d		12h 0m 0s
Long.	+	4h 0m 0s
G. A. T.		16h 0m 0s
Eq. T.	−	4m 42s
G. C. T. 15d		15h 55m 18s or
15d		15.9h
Dec. for 15d 14h		23° 17′.1
Corr. for 1.9h	+	.2
Dec. for 15d 15.9h		23° 17′.3 S

(Dec. and lat. same name, decl. greater)

Dec.		23° 17′ 18″ S
Alt. Corr.	+	10′ 12″
		23° 27′ 30″
		−90° 0′ 0″
Const.		66° 32′ 30″ N

Sun will cross the meridian when chronometer reads 3h 55m 18s P.M.
The Mer. Alt. Sun's L. L. is found to be 76° 10′ bearing S.
Const. 66° 32′ 30″ N − Obs. Alt. 76° 10′ S = Lat. 9° 37′ 30″ S.

CHAPTER XVI

LATITUDE BY MERIDIAN ALTITUDE OF FIXED STAR

The latitude of the observer may be obtained by fixed stars by the same methods as by observations of the sun—i.e., when the star is on the meridian or has reached its highest point for that day.

The method of finding the time of star's meridian passage is explained in next chapter.

RULE:

1. Take out star's declination from page 161, Nautical Almanac.

   NOTE.—The declination of a star has a very small annual change, so it is only necessary to take out the minutes for the month, and the number of degrees on the side opposite the star used.

2. Correct the star's altitude as follows:
   Index Error as per sign, if any.
   Dip (Table 14), subtract.
   Refraction (Table 20A), subtract.
   Answer will be true altitude.

3. Subtract true altitude from 90°. Answer will be Zenith Distance, to be named opposite the star's bearing.

4. Under Z. D. put down Dec. and apply as follows:
   Same names, add.
   Opposite names, subtract less from greater.
   Result will be latitude.

5. Name the latitude as follows:
   If added, will be named the same as the two of them.
   If subtracted, will be named the same as greater of two.

PROBLEM NO. 1

Nov. 12, 1936. Obs. Mer. Alt. *Rigel 26° 47′ 10″ S. Index Error −1′ 20″. Dip 18 ft. Required Lat.?

Dec. 8° 16′.2 S

Obs. Alt.	26° 47′ 10″		90° 0′ 0″
I. E.	− 1′ 20″	True Alt.	26° 39′ 46″ S
	26° 45′ 50″	Z. D.	63° 20′ 14″ N
Dip	− 4′ 9″	Dec.	8° 16′ 12″ S
	26° 41′ 41″	Lat.	55° 4′ 2″ N
Ref.	− 1′ 55″		
True Alt.	26° 39′ 46″ S		

PROBLEM NO. 2

Feb. 12, 1936. Obs. Mer. Alt. *Procyon 77° 18′ 10″ S. Index Error +20″. Dip 16 ft. Required Lat.?

Dec. 5° 23′.3 N

Obs. Alt.	77° 18′ 10″		90° 0′ 0″
I. E.	+ 20″	True Alt.	77° 14′ 22″ S
	77° 18′ 30″	Z. D.	12° 45′ 38″ N
Dip	− 3′ 55″	Dec.	5° 23′ 18″ N
	77° 14′ 35″	Lat.	18° 8′ 56″ N
Ref.	− 13″		
True Alt.	77° 14′ 22″ S		

PROBLEM NO. 3

March 19, 1936. Obs. Mer. Alt. *Arcturus 36° 10′ 20″ N. Index Error +2′ 40″. Dip 20 ft. Required Lat.?

Dec. 19° 30′.5 N

Obs. Alt.	36° 10′ 20″		90° 0′ 0″
I. E.	+ 2′ 40″	True Alt.	36° 7′ 17″ N
	36° 13′ 0″	Z. D.	53° 52′ 43″ S
Dip	− 4′ 23″	T. D.	19° 30′ 30″ N
	36° 8′ 37″	Lat.	34° 22′ 13″ S
Ref.	− 1′ 20″		
True Alt.	36° 7′ 17″ N		

PROBLEM NO. 4

July 9, 1936. Obs. Mer. Alt. *Spica 49° 16′ 25″ S. Dip 18 ft. Required Lat.?

Dec. 10° 50′.0 S

Obs. Alt.	49° 16′ 25″		90° 0′ 0″
Dip	− 4′ 9″	True Alt.	49° 11′ 26″ S
	49° 12′ 16″	Z. D.	40° 48′ 34″ N
Ref.	− 50″	T. D.	10° 50′ 0″ S
True Alt.	49° 11′ 26″ S	Lat.	29° 58′ 34″ N

PROBLEM NO. 5

March 11, 1936. Obs. Mer. Alt. *Betelgeux 80° 10′ 20″ N. Dip 30 ft. Required Lat.?

Dec. 7° 23′.8 N

Obs. Alt.	80° 10′ 20″		90° 0′ 0″
Dip	− 5′ 22″	True Alt.	80° 4′ 48″ N
	80° 4′ 58″	Z. D.	9° 55′ 12″ S
Ref.	− 10″	T. D.	7° 23′ 48″ N
True Alt.	80° 4′ 48″ N	Lat.	2° 31′ 24″ S

PROBLEM NO. 6

Feb. 16, 1936. Obs. Mer. Alt. *Aldebaran 38° 15′ S. Dip 28 ft. Required Lat.?

Dec. 16° 23′.0 N

Obs. Alt.	38° 15′ 0″		90° 0′ 0″
Dip	− 5′ 11″	True Alt.	38° 8′ 35″ S
	38° 9′ 49″	Z. D.	51° 51′ 25″ N
Ref.	− 1′ 14″	T. D.	16° 23′ 0″ N
True Alt.	38° 8′ 35″ S	Lat.	68° 14′ 25″ N

PROBLEM NO. 7

Nov. 21, 1936. Obs. Mer. Alt. *Sirius 41° 16′ S. Dip 40 ft. Required Lat.?

Dec. 16° 37′.7 S

Obs. Alt.	41° 16′ 0″		90° 0′ 0″
Dip	− 6′ 12″	True Alt.	41° 8′ 41″ S
	41° 9′ 48″	Z. D.	48° 51′ 19″ N
Ref.	− 1′ 7″	T. D.	16° 37′ 42″ S
True Alt.	41° 8′ 41″ S	Lat.	32° 13′ 37″ N

PROBLEM NO. 8

April 6, 1936. Obs. Mer. Alt. *Fomalhaut 18° 17′ S. Dip 28 ft. Required Lat.?

Dec. 29° 57′.6 S

Obs. Alt.	18° 17′ 0″		90° 0′ 0″
Dip	− 5′ 11″	True Alt.	18° 8′ 53″ S
	18° 11′ 49″	Z. D.	71° 51′ 7″ N
Ref.	− 2′ 56″	T. D.	29° 57′ 36″ S
True Alt.	18° 8′ 53″ S	Lat.	41° 53′ 31″ N

PROBLEM NO. 9

May 12, 1936. Obs. Mer. Alt. *Antares 80° 16′ N. Dip 20 ft. Required Lat.?

Dec. 26° 17′.6 S

Obs. Alt.	80° 16′ 0″		90° 0′ 0″
Dip	− 4′ 23″	True Alt.	80° 11′ 27″ N
	80° 11′ 37″	Z. D.	9° 48′ 33″ S
Ref.	− 10″	T. D.	26° 17′ 36″ S
True Alt.	80° 11′ 27″ N	Lat.	36° 6′ 9″ S

PROBLEM NO. 10

July 16, 1936. Obs. Mer. Alt. *Fomalhaut 73° 36′ S. Index Error +1′ 40″. Dip 24 ft. Required Lat.?

Dec. 29° 57′.3 S

Obs. Alt.	73° 36′ 0″		90° 0′ 0″
I. E.	+ 1′ 40″	True Alt.	73° 32′ 35″ S
	73° 37′ 40″	Z. D.	16° 27′ 25″ N
Dip	− 4′ 48″	T. D.	29° 57′ 18″ S
	73° 32′ 52″	Lat.	13° 29′ 53″ S
Ref.	− 17″		
True Alt.	73° 32′ 35″ S		

PROBLEM NO. 11

April 6, 1936. Obs. Mer. Alt. *Regulus 50° 14′ 20″ S. Index Error +1′ 15″. Dip 18 ft. Required Lat.?

Dec. 12° 16′.6 N

Obs. Alt.	50° 14′ 20″		90° 0′ 0″
I. E.	+ 1′ 15″	True Alt.	50° 10′ 37″ S
	50° 15′ 35″	Z. D.	39° 49′ 23″ N
Dip	− 4′ 9″	T. D.	12° 16′ 36″ N
	50° 11′ 26″	Lat.	52° 5′ 59″ N
Ref.	− 49″		
True Alt.	50° 10′ 37″ S		

PROBLEM NO. 12

Dec. 26, 1936. Obs. Mer. Alt. *Sirius 36° 28′ 30″ S. Index Error −45″. Dip 16 ft. Required Lat.?

Dec. 16° 37′.8 S

Obs. Alt.	36° 28′ 30″		90° 0′ 0″
I. E.	− 45″	True Alt.	36° 22′ 31″ S
	36° 27′ 45″	Z. D.	53° 37′ 29″ N
Dip	− 3′ 55″	T. D.	16° 37′ 48″ S
	36° 23′ 50″	Lat.	36° 59′ 41″ N
Ref.	− 1′ 19″		
True Alt.	36° 22′ 31″ S		

CHAPTER XVII

MERIDIAN PASSAGE OF FIXED STAR

This problem is to find the time a star will cross the meridian of the observer, in order to take an observation for latitude.

It will give the local civil time of transit very closely, but if it is desired to find the exact time it will be necessary to apply a further correction of 10s for every 15° of longitude, added in East Long., subtracted in West Long.

RULE:

1. From pages 162–209 (N. A.) take out G. C. T. of transit of the star for the first day of the month.
2. Subtract from this time the correction given on page 213 (N. A.) for the day of the month, to reduce the time to the date of the observation.
3. This will be Local Civil Time of Transit, very closely.

NOTE.—The stars in this table are given by their constellation name.

PROBLEM NO. 1

Nov. 12, 1936. Find Meridian Passage *Rigel.

G. C. T. of Transit Nov. 1		2h 31m
Corr. for 12d	−	43m
L. C. T. of Transit Nov. 12		1h 48m A. M.

PROBLEM NO. 2

Feb. 12, 1936. Find Meridian Passage *Procyon.

G. C. T. of Transit Feb. 1		22h 52m
Corr. for 12d	−	43m
L. C. T. of Transit Feb. 12		22h 9m or 10h 9m P. M.

PROBLEM NO. 11

April 6, 1936. Obs. Mer. Alt. *Regulus 50° 14′ 20″ S. Index Error +1′ 15″. Dip 18 ft. Required Lat.?

Dec. 12° 16′.6 N

Obs. Alt.	50° 14′ 20″		90° 0′ 0″
I. E.	+ 1′ 15″	True Alt.	50° 10′ 37″ S
	50° 15′ 35″	Z. D.	39° 49′ 23″ N
Dip	− 4′ 9″	T. D.	12° 16′ 36″ N
	50° 11′ 26″	Lat.	52° 5′ 59″ N
Ref.	− 49″		
True Alt.	50° 10′ 37″ S		

PROBLEM NO. 12

Dec. 26, 1936. Obs. Mer. Alt. *Sirius 36° 28′ 30″ S. Index Error −45″. Dip 16 ft. Required Lat.?

Dec. 16° 37′.8 S

Obs. Alt.	36° 28′ 30″		90° 0′ 0″
I. E.	− 45″	True Alt.	36° 22′ 31″ S
	36° 27′ 45″	Z. D.	53° 37′ 29″ N
Dip	− 3′ 55″	T. D.	16° 37′ 48″ S
	36° 23′ 50″	Lat.	36° 59′ 41″ N
Ref.	− 1′ 19″		
True Alt.	36° 22′ 31″ S		

CHAPTER XVII

MERIDIAN PASSAGE OF FIXED STAR

This problem is to find the time a star will cross the meridian of the observer, in order to take an observation for latitude.

It will give the local civil time of transit very closely, but if it is desired to find the exact time it will be necessary to apply a further correction of 10s for every 15° of longitude, added in East Long., subtracted in West Long.

RULE:

1. From pages 162–209 (N. A.) take out G. C. T. of transit of the star for the first day of the month.
2. Subtract from this time the correction given on page 213 (N. A.) for the day of the month, to reduce the time to the date of the observation.
3. This will be Local Civil Time of Transit, very closely.

NOTE.—The stars in this table are given by their constellation name.

PROBLEM NO. 1

Nov. 12, 1936. Find Meridian Passage *Rigel.

G. C. T. of Transit Nov. 1		2h 31m
Corr. for 12d	−	43m
L. C. T. of Transit Nov. 12		1h 48m A. M.

PROBLEM NO. 2

Feb. 12, 1936. Find Meridian Passage *Procyon.

G. C. T. of Transit Feb. 1		22h 52m
Corr. for 12d	−	43m
L. C. T. of Transit Feb. 12		22h 9m or 10h 9m P. M.

5. Correct observed altitude of sun as follows:
   Index error as per sign, if any.
   Semi-diameter from almanac. Add for lower limb, subtract for upper limb.
   Dip (Table 14), subtract.
   Refraction and parallax (Table 20B), subtract.
   Answer will be true altitude.
6. Add together true altitude, latitude and polar distance, and divide sum by 2. Answer will be half sum.
7. Subtract true altitude from half sum. Answer will be remainder.
8. From Table 44 (Bowditch) take out the following logarithms to the nearest second of arc:
   Secant of latitude. Rejecting 10 from index number.
   Cosecant of polar distance. Rejecting 10 from index number. (See note.)
   Cosine of half sum.
   Sine of remainder.
   Add these four logarithms together, and subtract 10 from index number.

   NOTE.—If Polar distance exceeds 90° take secant of true declination instead.
9. Logarithm Haversine (Table 45) that agrees with sum of logs will be the Local Apparent Time, expressed L. A. T.
   If sight was taken in A. M. read hours and minutes from bottom, and seconds in right-hand column, subtracting 12 from the hours.
   If sight was taken in P. M. read hours and minutes from top, and seconds in left-hand column, and add 12 to the hours.
10. Under L. A. T. put down G. A. T. If both are same date, subtract less from greater; if different dates, add 24 hours to greater date, and then subtract less from greater. Answer will be longitude in time.
11. Reduce longitude in time to arc, as explained in arithmetic of navigation.
12. Name the longitude as follows:
    If the Greenwich time is best, the longitude is west.
    If the Greenwich time is least, the longitude is east.

FINDING GREENWICH DATE AND TIME

The Greenwich time and date are absolutely necessary to be found correctly in all examples in navigation.

In some of the problems given in this book the reading of the chronometer is given A. M. or P.M.; others, longitude by dead reckoning is given; in others the Greenwich date and time are given.

Below will be found the different methods that an example may be given, and an explanation of how the Greenwich date may be found.

If the chronometer reads A.M. and no longitude by D. R. is given, the Greenwich civil date and time will be the same as the example.

For example: Jan. 25th P. M. at ship. Chronometer read 10h 16m 28s A. M.

Greenwich date and time will be Jan. 25th 10h 16m 28s.

If chronometer reads P. M. and no longitude by D. R. is given, add 12 to the hours and date the same as example.

For example: Jan. 25th A. M. at ship. Chronometer read 1h 16m 28s P. M.

Greenwich date and time will be Jan. 25th 13h 16m 28s.

If the Greenwich date is given, the chronometer is put down in the following manner:

Jan. 25th A. M. at ship. Chronometer read Jan. 24th 23h 16m 28s.

Greenwich date and time will be Jan. 24th 23h 16m 28s.

If the approximate ship's time and longitude by D. R. are given in an example, and the chronometer reading without stating whether it is A. M. or P. M., the student must be able to determine whether the chronometer is A. M. or P. M.

For example, if problem was given in following manner:

Jan. 26th about 7 A. M. at ship. Longitude by D. R. 90° W. Chronometer read 1h 10m.

Now as the difference between ship's time and Greenwich time is the longitude in time, we have for the above example a longitude in time of 6 hours.

In west longitude the Greenwich time is the largest. So if it is about 7 A. M. at ship, it must be 1h 10m P. M. at Greenwich. Or, Greenwich Civil Date Jan. 26th 13h 10m.

Now presuming this example was in longitude by D. R. 90° E.

In east longitude the ship's time is the largest. So if it is about 7 A. M. at ship, it must be 1h 10m A. M. at Greenwich. Or, Greenwich Civil Date Jan. 26th 1h 10m.

This will explain practically all the methods of finding the Greenwich Civil Date, and if the student will read his problem carefully he should have no trouble. It must always be remembered that the Greenwich civil day begins at midnight and ends at midnight, and a 24-hour face clock must be imagined.

PROBLEM NO. 1

Jan. 31, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 13° 54′. Dip 36 ft. Chron. read 2h 46m 17s P. M., which was fast 34m 34s. Lat. 25° 44′ N. Required Long.?

Chron.	14h 46m 17s	Dec. 31d 14h	17° 36′.1
Fast	− 34m 34s	Corr. for .2h	− .1
G. C. T. 31d	14h 11m 43s	Dec. 31d 14.2h	17° 36′.0 S
Eq. Time	− 13m 29s		+90° 0′.0
G. A. T. 31d	13h 58m 14s	Pol. Dist.	107° 36′.0
Obs. Alt.	13° 54′ 0″		
S. D.	+ 16′ 16″		
	14° 10′ 16″		
Dip	− 5′ 53″		
	14° 4′ 23″		
R. & P.	− 3′ 40″		
True Alt. (h)	14° 0′ 43″		
Lat.	25° 44′ 0″	Sec	.04536
P. D.	107° 36′ 0″	Csc	.02082
	2)147° 20′ 43″		
Half Sum (s)	73° 40′ 21″	Cos	9.44890
h	14° 0′ 43″		
Rem. (s − h)	59° 39′ 38″	Sin	9.93604
		Log. Hav.	9.45112

L. A. T. 31d	7h 43m 6s
G. A. T. 31d	13h 58m 14s
Long.	6h 15m 8s or 93° 47′ 0″ W

PROBLEM NO. 2

Jan. 30, 1936. P. M. at ship. Obs. Alt. Sun's L. L. 18° 32′. Dip 36 ft. Chron. read 10h 42m 46s P. M., which was fast 34m 28s. Lat. 27° 12′ N. Required Long.?

Chron.	22h 42m 46s	Dec. 30d 22h	17° 47′.1
Fast	− 34m 28s	Corr. for .1h	− .1
G. C. T. 30d	22h 8m 18s	Dec. 30d 22.1h	17° 47′.0 S
Eq. Time	− 13m 22s		+90° 0′.0
G. A. T. 30d	21h 54m 56s	P. D.	107° 47′.0

Obs. Alt.	18° 32′ 0″		
S. D.	+ 16′ 16″		
	18° 48′ 16″		
Dip	− 5′ 53″		
	18° 42′ 23″		
R. & P.	− 2′ 43″		
h	18° 39′ 40″		
Lat.	27° 12′ 0″	Sec	.05089
P. D.	107° 47′ 0″	Csc	.02126
	2)153° 38′ 40″		
s	76° 49′ 20″	Cos	9.35788
h	18° 39′ 40″		
s − h	58° 9′ 40″	Sin	9.92918
		Log. Hav.	9.35921

L. A. T. 30d	15h 48m 32s
G. A. T. 30d	21h 54m 56s
Long.	6h 6m 24s or 91° 36′ W

PROBLEM NO. 3

March 11, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 28° 13′. Dip 38 ft. Chron. read 3h 12m 15s A. M. (Chron. correct.) Lat. 31° 46′ S. Required Long.?

G. C. T. 11d	3h 12m 15s		Dec. 11d 2h	3° 49′.8
Eq. Time	− 10m 15s		Corr. for 1.2h	− 1′.2
G. A. T. 11d	3h 2m 0s		Dec. 11d 3.2h	3° 48′.6 S
				−90° 0′.0
Obs. Alt.	28° 13′ 0″			
S. D.	+ 16′ 8″		P. D.	86° 11′.4
	28° 29′ 8″			
Dip	− 6′ 2″			
	28° 23′ 6″			
R. & P.	− 1′ 40″			
h	28° 21′ 26″			
Lat.	31° 46′ 0″		Sec	.07048
P. D.	86° 11′ 24″		Csc	.00096
	2)146° 18′ 50″			
s	73° 9′ 25″		Cos	9.46202
h	28° 21′ 26″			
s − h	44° 47′ 59″		Sin	9.84796
			Log. Hav.	9.38142

L. A. T. 11d	8h 4m 58s
G. A. T. 11d	3h 2m 0s
Long.	5h 2m 58s or 75° 44′ 30″ E

PROBLEM NO. 4

Jan. 31, 1936. P. M. at ship. Obs. Alt. Sun's L. L. 18° 32′. Dip 36 ft. Chron. read 10h 42m 46s A. M., which was fast 34m 28s. Lat. 27° 12′ N. Required Long.?

Chron.	10h 42m 46s		Dec. 31d 10h	17° 38′.8
Fast	− 34m 28s		Corr. for .1h	− .1
G. C. T. 31d	10h 8m 18s		Dec. 31d 10.1h	17° 38′.7 S
Eq. Time	− 13m 27s			+90° 0′.0
G. A. T. 31d	9h 54m 51s		P. D.	107° 38′.7

Obs. Alt.	18° 32′ 0″		
S. D.	+ 16′ 16″		
	18° 48′ 16″		
Dip	− 5′ 53″		
	18° 42′ 23″		
R. & P.	− 2′ 43″		
h	18° 39′ 40″		
Lat.	27° 12′	Sec	.05089
P. D.	107° 38′ 42″	Csc	.02093
	2)153° 30′ 22″		
s	76° 45′ 11″	Cos	9.36012
s − h	58° 5′ 31″	Sin	9.92885
		Log. Hav.	9.36079

L. A. T. 31d 15h 49m 0s
G. A. T. 31d 9h 54m 51s

Long. 5h 54m 9s or 88° 32′ 15″ E

PROBLEM NO. 5

March 10, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 21° 0′. Dip 38 ft. Chron. read 1h 7m 56s P. M. (Chron. correct.) Lat. 31° 19′ N. Required Long.?

G. C. T. 10d	13h 7m 56s	Dec. 10d 12h	4° 3′.5
Eq. Time	− 10m 24s	Corr. for 1.1h	− 1′.1
G. A. T. 10d	12h 57m 32s	Dec. 10d 13.1h	4° 2′.4 S
			+90° 0′.0
Obs. Alt.	21° 0′ 0″		
S. D.	+ 16′ 8″	P. D.	94° 2′.4
	21° 16′ 8″		
Dip	− 6′ 2″		
	21° 10′ 6″		
R. & P.	− 2′ 21″		
h	21° 7′ 45″		
Lat.	31° 19′	Sec	.06839
P. D.	94° 2′ 24″	Csc	.00108
	2)146° 29′ 9″		
s	73° 14′ 34″	Cos	9.45987
s − h	52° 6′ 49″	Sin	9.89720
		Log. Hav.	9.42654

L. A. T. 10d	7h 51m 5s
G. A. T. 10d	12h 57m 32s
Long.	5h 6m 27s or 76° 36′ 45″ W

PROBLEM NO. 6

July 5, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 18° 15′. Dip 38 ft. Chron. read 10h 15m 25s A. M., which was slow 12 m 10s. Lat. 37° 15′ N. Required Long.?

Chron.	10h 15m 25s	Dec. 5d 10h	22° 47′.7
Slow	+ 12m 10s	Corr. for .5h	− .1
G. C. T. 5d	10h 27m 35s	Dec. 5d 10.5h	22° 47′.6 N
Eq. Time	− 4m 22s		−90° 0′.0
G. A. T. 5d	10h 23m 13s	P. D.	67° 12′.4

Obs. Alt.	18° 15′ 0″		
S. D.	+ 15′ 46″		
	18° 30′ 46″		
Dip	− 6′ 2″		
	18° 24′ 44″		
R. & P.	− 2′ 45″		
h	18° 21′ 59″		
Lat.	37° 15′ 0″	Sec	.09909
P. D.	67° 12′ 24″	Csc	.03531
	2)122° 49′ 23″		
s	61° 24′ 41″	Cos	9.67990
s − h	43° 2′ 42″	Sin	9.83414
		Log. Hav.	9.64844

L. A. T. 5d	6h 25m 13s
G. A. T. 5d	10h 23m 13s
Long.	3h 58m 0s or 59° 30′ 0″ W

PROBLEM NO. 7

July 5, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 14° 28′ 30″. Dip 21 ft. Chron. read 4h 16m 28s A. M., slow 14m 28s. Lat. 26° 33′ N. Required Long.?

Chron.	4h 16m 28s	Dec. 5d 4h	22° 49′.1
Slow	+ 14m 28s	Corr. for .5h	− .1
G. C. T. 5d	4h 30m 56s	Dec. 5d 4.5h	22° 49′.0 N
Eq. Time	− 4m 20s		−90° 0′.0
G. A. T. 5d	4h 26m 36s	P. D.	67° 11′.0
Obs. Alt.	14° 28′ 30″		
S. D.	+ 15′ 46″		
	14° 44′ 16″		
Dip	− 4′ 29″		
	14° 39′ 47″		
R. & P.	− 3′ 30″		
h	14° 36′ 17″		
Lat.	26° 33′ 0″	Sec	.04840
P. D.	67° 11′ 0″	Csc	.03539
	2)108° 20′ 17″		
s	54° 10′ 8″	Cos	9.76745
s−h	39° 33′ 51″	Sin	9.80410
		Log. Hav.	9.65534

L. A. T. 5d	6h 21m 56s
G. A. T. 5d	4h 26m 36s
Long.	1h 55m 20s or 28° 50′ 0″ E

PROBLEM NO. 8

Jan. 31, 1936. P. M. at ship. Obs. Alt. Sun's L. L. 23° 16′. Dip 36 ft. Chron. read 10h 38m 38s P. M., which was fast 34m 37s. Lat. 24° 55′ N. Required Long.?

Chron.	22h 38m 38s	Dec. 31d 22h	17° 30′.6
Fast	− 34m 37s	Corr. for .1h	− .1
G. C. T. 31d	22h 4m 1s	Dec. 31d 22.1h	17° 30′.5 S
Eq. Time	− 13m 32s		+90° 0′.0
G. A. T. 31d	21h 50m 29s	P. D.	107° 30′.5

Obs. Alt.	23° 16′ 0″		
S. D.	+ 16′ 16″		
	23° 32′ 16″		
Dip	− 5′ 53″		
	23° 26′ 23″		
R. & P.	− 2′ 5″		
h	23° 24′ 18″		
Lat.	24° 55′ 0″	Sec	.04243
P. D.	107° 30′ 30″	Csc	.02060
	2)155° 49′ 48″		
s	77° 54′ 54″	Cos	9.32092
s−h	54° 30′ 36″	Sin	9.91074
		Log. Hav.	9.29469

L. A. T. 31d	15h 30m 51s
G. A. T. 31d	21h 50m 29s
Long.	6h 19m 38s or 94° 54′ 30″ W

PROBLEM NO. 9

Dec. 15, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 28° 16′ 15″. Dip 40 ft. Chron. read 4h 16m 28s P. M., which was slow 14m 28s. Lat. 26° 33′ S. Required Long.?

Chron.	16h 16m 28s	Dec. 15d 16h	23° 17′.3
Slow	+ 14m 28s	Corr. for .5h	+ .1
G. C. T. 15d	16h 30m 56s	Dec. 15d 16.5h	23° 17′.4 S
Eq. Time	+ 4m 41s		−90° 0′.0
G. A. T. 15d	16h 35m 37s	P. D.	66° 42′.6

Obs. Alt.	28° 16′ 15″		
S. D.	+ 16′ 17″		
	28° 32′ 32″		
Dip	− 6′ 12″		
	28° 26′ 20″		
R. & P.	− 1′ 39″		
h	28° 24′ 41″		
Lat.	26° 33′ 0″	Sec	.04840
P. D.	66° 42′ 36″	Csc	.03692
	2)121° 40′ 17″		
s	60° 50′ 8″	Cos	9.68781
s−h	32° 25′ 27″	Sin	9.72931
		Log. Hav.	9.50244

L. A. T. 15d	7h 25m 23s
G. A. T. 15d	16h 35m 37s
Long.	9h 10m 14s or 137° 33′ 30″ W

PROBLEM NO. 10

Oct. 24, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 18° 26′ 15″. Dip 40 ft. Chron. read 2h 8m 3s A. M., which was fast 58m 13s. Lat. 3° 21′ S. Required Long.?

Chron.	2h 8m 3s	Dec. 24d 0h	11° 37′.0
Fast	− 58m 13s	Corr. for 1.2h	+ 1′.1
G. C. T. 24d	1h 9m 50s	Dec. 24d 1.2h	11° 38′.1 S
Eq. Time	+ 15m 42s		−90° 0′.0
G. A. T. 24d	1h 25m 32s	P. D.	78° 21′.9

Obs. Alt.	18° 26′ 15″		
S. D.	+ 16′ 7″		
	18° 42′ 22″		
Dip	− 6′ 12″		
	18° 36′ 10″		
R. & P.	− 2′ 43″		
h	18° 33′ 27″		
Lat.	3° 21′ 0″	Sec.	.00074
P. D.	78° 21′ 54″	Csc	.00902
	2)100° 16′ 21″		
s	50° 8′ 10″	Cos	9.80683
s−h	31° 34′ 43″	Sin	9.71906
		Log. Hav.	9.53565

L. A. T. 24d	7h 13m 4s
G. A. T. 24d	1h 25m 32s
Long.	5h 47m 32s or 86° 53′ 0″ E

PROBLEM NO. 11

July 3, 1936. P. M. at ship. Obs. Alt. Sun's L. L. 23° 18′ 30″. Dip 39 ft. Chron. read 5h 32m 20s P. M., which was fast 28m 46s. Lat. 31° 12′ S. Required Long.?

Chron.	17h 32m 20s	Dec. 3d 16h	22° 56′.9
Fast	− 28m 46s	Corr. for 1.1h	− .2
G. C. T. 3d	17h 3m 34s	Dec. 3d 17.1h	22° 56′.7 N
Eq. Time	− 4m 4s		+90° 0′.0
G. A. T. 3d	16h 59m 30s	P. D.	112° 56′.7

Obs. Alt.	23° 18′ 30″		
S. D.	+ 15′ 46″		
	23° 34′ 16″		
Dip	− 6′ 7″		
	23° 28′ 9″		
R. & P.	− 2′ 5″		
h	23° 26′ 4″		
Lat.	31° 12′ 0″	Sec	.06785
P. D.	112° 56′ 42″	Csc	.03580
	2)167° 34′ 46″		
s	83° 47′ 23″	Cos	9.03415
s−h	60° 21′ 19″	Sin	9.93907
		Log. Hav.	9.07687

L. A. T. 3d	14h 41m 42s
G. A. T. 3d	16h 59m 30s
Long.	2h 17m 48s or 34° 27′ 0″ W

PROBLEM NO. 12

March 21, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 37° 18′. Dip 40 ft. Chron. read 9h 46m 16s A. M., which was fast 38m 12s. Lat. 46° 40′ S. Required Long.?

Chron.	9h 46m 16s	Dec. 21d 8h	0° 12′.9
Fast	− 38m 12s	Corr. for 1.1h	+ 1′.1
G. C. T. 21d	9h 8m 4s	Dec. 21d 9.1h	0° 14′.0 N
Eq. Time	− 7m 20s		+90° 0′.0
G. A. T. 21d	9h 0m 44s	P. D.	90° 14′.0

Obs. Alt.	37° 18′ 0″		
S. D.	+ 16′ 5″		
	37° 34′ 5″		
Dip	− 6′ 12″		
	37° 27′ 53″		
R. & P.	− 1′ 9″		
h	37° 26′ 44″		
Lat.	46° 40′	Sec	.16352
P. D.	90° 14′ 0″	Csc	.00000
	2)174° 20′ 44″		
s	87° 10′ 22″	Cos	8.69306
s−h	49° 43′ 38″	Sin	9.88251
		Log. Hav.	8.73909

L. A. T. 21d	10h 11m 39s
G. A. T. 21d	9h 0m 44s
Long.	1h 10m 55s or 17° 43′ 45″ E

CHAPTER XIX

LONGITUDE BY SUN—TO FIND NOON POSITION

The following problems are worked the same as the foregoing sights for longitude, as far as obtaining the longitude at sight.

In working an observation for longitude the correct latitude at time of observation must be used.

In these problems the latitude at noon is given, and the latitude at time of observation must be found by taking from Table 2 (Bowditch) the difference of latitude and departure for the course and distance run in the interval between observation and noon.

If the observation is taken in A. M. the name of the latitude difference north or south must be reversed to work the latitude back to sight.

If taken in P. M. the name of latitude difference remains the same.

By applying the difference of latitude to latitude at noon will be found the latitude at sight, which is the latitude to be used in working the problem.

The middle latitude is then found by adding together latitude at noon and latitude at sight, and dividing sum by 2.

Enter Table 2 with middle latitude as a course and look for departure in latitude column. In the distance column opposite will be difference of longitude in minutes.

If sight is taken in P. M. the name of the difference of longitude east or west must be reversed to work the problem back to noon.

If sight is A. M. the name of difference of longitude stays the same.

The chronometer is corrected for the original error, slow or fast, and the number of days and tenths of days from date of original error to Greenwich Civil Date and time are figured out, and multiplied by daily rate; this will give the accumulated rate.

The accumulated rate is then applied to chronometer time, and the result will be G. C. T.

The example is then worked as in previous longitude problem, and longitude at sight is obtained.

By applying the difference of longitude to the longitude at sight the longitude at noon will be obtained.

This will give ship's noon position.

PROBLEM NO. 1

Feb. 10, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 9° 9′ 50″. Index Error −3′ 20″. Dip 18 ft. Chron. read Feb. 9, 9h 59m 25s P. M., which was fast on Jan. 10 (midnight) 34m 12s and losing 10s.8 daily. Lat. at noon was 50° 16′ 24″ N. Ship ran from sight to noon 236° (true) 38 miles. Required position of vessel at sight and noon?

Chron.		21h 59m 25s		Interval 30.9 days	
Fast	−	34m 12s		D. R. 10s.8×30.9=334s or	
				Acc. Rate losing 5m 34s	
		21h 25m 13s			
Acc. Rate	+	5m 34s			
G. C. T. 9d		21h 30m 47s		Dec. 9d 20h	14° 50′.8
Eq. Time	−	14m 21s		Corr. for 1.5h	− 1′.2
G. A. T. 9d		21h 16m 26s		Dec. 9d 21.5h	14° 49′.6 S
					+90° 0′.0
				P. D.	104° 49′.6
Obs. Alt.		9° 9′ 50″			
I. E.	−	3′ 20″			
		9° 6′ 30″			
Corr. (46)	+	6′ 26″		Lat. Noon	50° 16′ 24″ N
				Diff. Lat.	21′ 12″ N
h		9° 12′ 56″			
Lat.		50° 37′ 36″	Sec	.19765	Lat. Sight 50° 37′ 36″ N
P. D.		104° 49′ 36″	Csc	.01471	
		2)164° 40′ 8″			At Mid. Lat. 50°; Dep.
s		82° 20′ 4″	Cos	9.12513	31.5=Diff. Long. 49′ W
s−h		73° 7′ 8″	Sin	9.98087	
				Log.Hav.9.31836	

L. A. T. 10d	8h 22m 51s (+24h)	
G. A. T. 9d	21h 16m 26s	
Long. Sight	11h 6m 25s or	166° 36′ 15″ E
Diff. Long.		49′ W
Long. at Noon		165° 47′ 15″ E

PROBLEM NO. 2

Jan. 31, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 15° 8′. Dip 36 ft. Chron. read 2h 45m 49s P. M., which was fast on Jan. 11, 31m 34s and gaining 9s daily. Lat. at noon 25° 31′ 17″ N. Ship ran from sight to noon S 26° W (true) 57 miles. Required position at sight and noon?

Chron.	14h 45m 49s			Interval 20.6 days	
Fast	− 31m 34s			D. R. 9s × 20.6 = 185s	
	14h 14m 15s			Acc. Rate gaining 3m 5s	
Acc. Rate	− 3m 5s				
G. C. T. 31d	14h 11m 10s			Dec. 31d 14h	17° 36′.1
Eq. Time	− 13m 29s			Corr. for .2h	− .1
G. A. T. 31d	13h 57m 41s			Dec. 31d 14.2h	17° 36′.0 S
					+90° 0′.0
				P. D.	107° 36′.0
Obs. Alt.	15° 8′ 0″				
Corr. (46)	+ 7′ 0″			Lat. Noon	25° 31′ 17″ N
				Diff. Lat.	51′ 12″ N
h	15° 15′ 0″				
Lat.	26° 22′ 29″	Sec	.04774	Lat. Sight	26° 22′ 29″ N
P. D.	107° 36′ 0″	Csc	.02082		
	2)149° 13′ 29″			At Mid. Lat.	26°; Dep.
s	74° 36′ 44″	Cos	9.42383	25.0 = Diff. Long.	28′ W
s − h	59° 21′ 44″	Sin	9.93470		
		Log. Hav.	9.42709		

L. A. T. 31d	7h 50m 55s		
G. A. T. 31d	13h 57m 41s		
Long. Sight	6h 6m 46s	or	91°41′ 30″ W
Diff. Long.			28′ 0″ W
Long. Noon			92° 9′ 30″ W

PROBLEM NO. 3

Jan. 2, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 49° 10′. Index Error −2′ 40″. Dip 14 ft. Chron. read 7h 8m 50s A. M., which was slow on Dec. 7, 19m 10s and losing 9s.8 daily. Lat. at noon 37° 21′ 36″ S. Ship ran from sight to noon 225° (true) 32 miles. Required position at sight and noon?

Chron.	7h 8m 50s			Interval 26.3 days	
Slow +	19m 10s			D. R. 9s.8 × 26.3 = 258s	
	7h 28m 0s			Acc. Rate losing 4m 18s	
Acc. Rate +	4m 18s				
G. C. T. 2d	7h 32m 18s			Dec. 2d 6h	23° 1′.1
Eq. Time −	3m 38s			Corr. for 1.5h	− .3
G. A. T. 2d	7h 28m 40s			Dec. 2d 7.5h	23° 0′.8 S
					−90° 0′.0
				P. D.	66° 59′.2
Obs. Alt.	49° 10′ 0″				
I. E.	− 2′ 40″				
	49° 7′ 20″			Lat. Noon	37° 21′ 36″ S
Corr. (46)	+ 11′ 54″			Diff. Lat.	22′ 36″ N
h	49° 19′ 14″			Lat. Sight	36° 59′ 0″ S
Lat.	36° 59′ 0″	Sec	.09756		
P. D.	66° 59′ 12″	Csc	.03602		
	2)153° 17′ 26″			At Mid. Lat. 37°; Dep.	
s	76° 38′ 43″	Cos	9.36357	22.6 = Diff. Long. 28′ W	
s—h	27° 19′ 29″	Sin	9.66185		
		Log. Hav.	9.15900		
	L. A. T. 2d	9h 1m 27s			
	G. A. T. 2d	7h 28m 40s			
	Long. Sight	1h 32m 47s	or	23° 11′ 45″ E	
	Diff. Long.			28′ 00″ W	
	Long. Noon			22° 43′ 45″ E	

PROBLEM NO. 4

Oct. 17, 1936. P. M. at ship. Obs. Alt. Sun's L. L. 16° 19′ 15″. Dip 28 ft. Chron. read 11h 55m 3s P. M., which was fast on Sept. 23, 8m 23s and gaining 8s.2 daily. Lat. at noon 22° 35′ 48″ S. Ship ran from noon to sight 342° (true) 42 miles. Required position at sight and noon?

Chron.	23h 55m 3s			Interval 25 days	
Fast	− 8m 23s			D. R. 8s.2×25 = 205s	
	23h 46m 40s			Acc. Rate gaining 3m 25s	
Acc. Rate	− 3m 25s				
G. C. T. 17d	23h 43m 15s			Dec. 17d 22h	9° 26′.5
Eq. Time	+ 14m 42s			Corr. for 1.7h	+ 1′.5
G. A. T. 17d	23h 57m 57s			Dec. 17d 23.7h	9° 28′.0 S
					−90° 0′.0
				P. D.	80° 32′.0
Obs. Alt.	16° 19′ 15″				
Corr. (46)	+ 7′ 48″				
h	16° 27′ 3″				
Lat.	21° 55′ 54″	Sec	.03262	Lat. Noon	22° 35′ 48″ S
P. D.	80° 32′ 0″	Csc	.00596	Diff. Lat.	39′ 54″ N
	2)118° 54′ 57″				
S	59° 27′ 28″	Cos	9.70601	Lat. Sight	21° 55′ 54″ S
s−h	43° 0′ 25″	Sin	9.83384		
				At Mid. Lat. 22°; Dep.	
		Log.Hav.	9.57843	13.0 = Diff. Long.	14′ E

L. A. T. 17d	17h 3m 54s		
G. A. T. 17d	23h 57m 57s		
Long. Sight	6h 54m 3s	or	103° 30′ 45″ W
Diff. Long.			14′ 0″ E
Long. Noon			103° 16′ 45″ W

PROBLEM NO. 5

Dec. 1, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 15° 18′ 12″. Dip 26 ft. Chron. read Nov. 30, 9h 2m 5s P. M., which was slow on Nov. 10, 3m 55s and gaining 7s.8 daily. Lat. at noon was 18° 16′ N. Ship ran from sight to noon N 28° E (true) 58 miles. Required position at sight and noon?

Chron.	21h 2m 5s			Interval 20.9 days	
Slow	+ 3m 55s			D. R. 7s.8 × 20.9 = 163s	
				Acc. Rate gaining 2m 43s	
	21h 6m 0s				
Acc. Rate	− 2m 43s				
G. C. T. 30d	21h 3m 17s			Dec. 30d 20h	21° 43′.4
Eq. Time	+ 11m 8s			Corr. for 1.1h	+ .4
G. A. T. 30d	21h 14m 25s			Dec. 30d 21.1h	21° 43′.8 S
					+ 90° 0′.0
Obs. Alt.	15° 18′ 12″			P. D.	111° 43′.8
Corr. (46)	+ 7′ 55″				
				Lat. at Noon	18° 16′ 0″ N
h	15° 26′ 7″			Diff. Lat.	51′ 12″ S
Lat.	17° 24′ 48″	Sec	.02037		
P. D.	111° 43′ 48″	Csc	.03201	Lat. at Sight	17° 24′ 48″ N
	2)144° 34′ 43″				
s	72° 17′ 21″	Cos	9.48318	At Mid. Lat. 18°; 27.2 =	
s − h	56° 51′ 14″	Sin	9.92287	Diff. Long. 28′.5 E	
		Log.Hav.	9.45843		

L. A. T. 1d	7h 40m 40s (+24h)		
G. A. T. 30d	21h 14m 25s		
Long. at Sight	10h 26m 15s	or	156° 33′ 45″ E
Diff. Long.			28′ 30″ E
Long. at Noon			157° 2′ 15″ E

PROBLEM NO. 6

May 3, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 28° 49′. Dip 30 ft. Chron. read 8h 3m 2s A. M., which was slow on April 7, 3m 28s and gaining 2s.8 daily. Lat. at noon was 28° 16′ 28″ N. Ship ran from sight to noon 249° (true) 73 miles. Required position at sight and noon?

Chron.		8h 3m 2s		Interval 26.3 days	
Slow	+	3m 28s		D. R. 2s.8 × 26.3 = 74s	
		8h 6m 30s		Acc. Rate gaining 1m 14s	
Acc. Rate	−	1m 14s			
G. C. T. 3d		8h 5m 16s		Dec. 3d 8h	15° 39′.4
Eq. Time	+	3m 9s		Corr. for .1h	+ .1
G. A. T. 3d		8h 8m 25s		Dec. 3d 8.1h	15° 39′.5 N
					−90° 0′.0
Obs. Alt.		28° 49′ 0″		P. D.	74° 20′.5
Corr. (46)	+	8′ 53″			
h		28° 57′ 53″			Lat. Noon 28° 16′ 28″ N
Lat.		28° 42′ 40″	Sec	.05698	Diff. Lat. 26′ 12″ N
P. D.		74° 20′ 30″	Csc	.01642	
		2)132° 1′ 3″			Lat. Sight 28° 42′ 40″ N
s		66° 0′ 31″	Cos	9.60916	At Mid. Lat. 28°; Dep.
s − h		37° 2′ 38″	Sin	9.77990	68.2 = Diff. Long. 77′ W
			Log. Hav.	9.46246	

L. A. T. 3d	7h 39m 19s		
G. A. T. 3d	8h 8m 25s		
Long. at Sight	29m 6s	or	7° 16′ 30″ W
Diff. Long.			1° 17′ 0″ W
Long. at Noon			8° 33′ 30″ W

PROBLEM NO. 7

April 23, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 23° 15′. Dip 26 ft. Chron. read 0h 3m 12s A. M., which was slow on March 16, 4m 28s and gaining 11s.7 daily. Lat. at noon was 27° 23′ S. Ship ran from sight to noon 28° (true) 62 miles. Required position at sight and noon?

Chron.		0h 3m 12s			Interval 38 days	
Slow	+	4m 28s			D. R. 11s.7 × 38 = 445s	
		0h 7m 40s			Acc. Rate gaining 7m 25s	
Acc. Rate	−	7m 25s				
G. C. T. 23d		0h 0m 15s			Dec. 23d 0h	12° 24′.0 N
Eq. Time	+	1m 35s				+ 90° 0′.0
G. A. T. 23d		0h 1m 50s			P. D.	102° 24′.0
Obs. Alt.		23° 15′ 0″				
Corr. (46)	+	8′ 47″				
h		23° 23′ 47″			Lat. Noon	27° 23′ 0″ S
Lat.		28° 17′ 42″	Sec	.05526	Diff. Lat.	54′ 42″ S
P. D.		102° 24′ 0″	Csc	.01025		
		2)154° 5′ 29″			Lat. Sight	28° 17′ 42″ S
s		77° 2′ 44″	Cos	9.35057	At Mid. Lat. 28°; Dep.	
s − h		53° 38′ 57″	Sin	9.90601	29.1 = Diff. Long.	33′ E
			Log. Hav.	9.32209		

L. A. T. 23d	8h 21m 50s		
G. A. T. 23d	0h 1m 50s		
Long. at Sight	8h 20m 0s	or	125° 0′ E
Diff. Long.			33′ E
Long. at Noon			125° 33′ E

PROBLEM NO. 8

Nov. 28, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 50° 25′. Dip 30 ft. Chron. read 9h 33m 10s A. M., which was fast on Oct. 22, 3m 28s and losing 4s.7 daily. Lat. at noon was 0° 10′ 30″ N. Ship ran from sight to noon N 79° E (true) 31 miles. Required position at sight and noon?

Chron.	9h 33m 10s			Interval 37.4 days	
Fast	− 3m 28s			D. R. 4s.7 × 37.4 = 176s	
	9h 29m 42s			Acc. Rate losing 2m 56s	
Acc. Rate	+ 2m 56s				
G. C. T. 28d	9h 32m 38s			Dec. 28d 8h	21° 18′.2
Eq. Time	+ 12m 1s			Corr. for 1.5h	+ .6
G. A. T. 28d	9h 44m 39s			Dec. 28d 9.5h	21° 18′.8 S
					+ 90° 0′.0
				P. D.	111° 18′.8
Obs. Alt.	50° 25′ 0″			Lat. at Noon	0° 10′ 30″ N
Corr. (46)	+ 10′ 10″			Diff. Lat.	5′ 54″ S
h	50° 35′ 10″			Lat. at Sight	0° 4′ 36″ N
Lat.	4′ 36″	Sec	.00000	Dep. 30.4 = Diff. Long.	
P. D.	111° 18′ 48″	Csc	.03077	30′.4 E	
	2)161° 58′ 34″				
s	80° 59′ 17″	Cos	9.19492		
s − h	30° 24′ 7″	Sin	9.70421		
		Log. Hav.	8.92990		

L. A. T. 28d	9h 44m 19s		
G. A. T. 28d	9h 44m 39s		
Long. at Sight	20s	or	0° 5′ 0″ W
Diff. Long.			30′ 24″ E
Long. at Noon			0° 25′ 24″ E

PROBLEM NO. 9

March 21, 1936. P. M. at ship. Obs. Alt. Sun's L. L. 34° 17′ 30″. Dip 36 ft. Chron. read 9h 45m 17s A. M., which was fast on Feb. 27. 1h 6m and losing 9s.5 daily. Lat. at noon was 23° 15′ S. Ship ran from noon to sight N 24° W (true) 56 miles. Required position at sight and noon?

Chron.	9h 45m 17s			Interval 23.4 days	
Fast	− 1h 6m			D. R. 9s.5 × 23.4 = 222s	
	8h 39m 17s			Acc. Rate losing 3m 42s	
Acc. Rate	+ 3m 42s				
G. C. T. 21d	8h 42m 59s			Dec. 21d 8h	0° 12′.9
Eq. Time	− 7m 20s			Corr. for .7h	+ .7
G. A. T. 21d	8h 35m 39s			Dec. 21d 8.7h	0° 13′.6 N
					+90° 0′.0
Obs. Alt.	34° 17′ 30″			P. D.	90° 13′.6
Corr. (46)	+ 8′ 54″				
h	34° 26′ 24″			Lat. Noon	23° 15′ 0″ S
Lat.	22° 23′ 48″	Sec	.03406	Diff. Lat.	51′ 12″ N
P. D.	90° 13′ 36″				
	2)147° 3′ 48″	Csc	.00000	Lat. Sight	22° 23′ 48″ S
s	73° 31′ 54″	Cos	9.45254	At Mid. Lat. 23°; Dep.	
s − h	39° 5′ 30″	Sin	9.79973	22.8 = Diff. Long.	25′ E
		Log. Hav.	9.28633		
	L. A. T. 21d	15h 28m 41s			
	G. A. T. 21d	8h 35m 39s			
	Long. at Sight	6h 53m 2s	or	103° 15′ 30″ E	
	Diff. Long.			25′ E	
	Long. at Noon			103° 40′ 30″ E	

PROBLEM NO. 10

Sept. 30, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 38° 16′ 46″. Dip 24 ft. Chron. read 11h 17m 25s P. M., which was fast on Aug. 28, 2h 15m and gaining 4s.7 daily. Lat. at noon was 41° 16′ N. Ship ran from sight to noon 264° (true) 63 miles. Required position at sight and noon?

Chron.	23h 17m 25s			Interval 33.9 days	
Fast	− 2h 15m			D. R. 4s.7 × 33.9 = 159s	
	21h 2m 25s			Acc. Rate gaining 2m 39s	
Acc. Rate	− 2m 39s				
G. C. T. 30d	20h 59m 46s			Dec. 30d 20h	2° 57′.8
Eq. Time	+ 10m 8s			Corr. for 1h	+ 1′.0
G. A. T. 30d	21h 9m 54s			Dec. 30d 21h	2° 58′.8 S
					+90° 0′.0
				P. D.	92° 58′.8
Obs. Alt.	38° 16′ 46″				
Corr. (46)	+ 10′ 6″				
h	38° 26′ 52″			Lat. Noon	41° 16′ 0″ N
Lat.	41° 22′ 36″	Sec	.12472	Diff. Lat.	6′ 36″ N
P. D.	92° 58′ 48″	Csc	.00059		
	2)172° 48′ 16″			Lat. Sight	41° 22′ 36″ N
s	86° 24′ 8″	Cos	8.79762	At Mid. Lat. 41°; Dep.	
s − h	47° 57′ 16″	Sin	9.87076	62.7 = Diff. Long.	83′ W
		Log. Hav.	8.79369		

L. A. T. 30d	10h 4m 29s			
G. A. T. 30d	21h 9m 54s			
Long. at Sight	11h 5m 25s	or	166° 21′ 15″ W	
Diff. Long.			1° 23′ 00″ W	
Long. at Noon			167° 44′ 15″ W	

PROBLEM NO. 11

Feb. 27, 1936. P. M. at ship. Obs. Alt. Sun's L. L. 13° 18′. Dip 31 ft. Chron. read 5h 46m 15s A. M., which was slow on Jan. 4, 7m 18s and gaining 4s.3 daily. Lat. at noon was 14° 27′ N. Ship ran from noon to sight 47° (true) 39 miles. Required position at sight and noon?

Chron.		5h 46m 15s		Interval 54.2 days	
Slow	+	7m 18s		D. R. 4s.3 × 54.2 = 233s	
		5h 53m 33s		Acc. Rate gaining 3m 53s	
Acc. Rate	−	3m 53s			
G. C. T. 27d		5h 49m 40s		Dec. 27d 4h	8° 47′.7
Eq. Time	−	13m 5s		Corr. for 1.8h	− 1′.6
G. A. T. 27d		5h 36m 35s		Dec. 27d 5.8h	8° 46′.1 S
					+90° 0′.0
				P. D.	98° 46′.1
Obs. Alt.		13° 18′ 0″		Lat. at Noon	14° 27′ 0″ N
Corr. (46)	+	6′ 52″		Diff. Lat.	26′ 36″ N
h		13° 24′ 52″		Lat. at Sight	14° 53′ 36″ N
Lat.		14° 53′ 36″	Sec .01484	At Mid. Lat. 15°;	
				Dep. 28.5 =	
P. D.		98° 46′ 6″	Csc .00510	Diff. Long.	29′.5 W
		2)127° 4′ 34″			
s		63° 32′ 17″	Cos 9.64895		
s − h		50° 7′ 25″	Sin 9.88503		
			Log. Hav. 9.55392		
		L. A. T. 27d	16h 54m 1s		
		G. A. T. 27d	5h 36m 35s		
		Long. at Sight	11h 17m 26s	or	169° 21′ 30″ E
		Diff. Long.			29′ 30″ W
		Long. at Noon			168° 52′ 0″ E

PROBLEM NO. 12

Oct. 3, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 28° 46′. Dip 29 ft. Chron. read 1h 28m 16s P. M., which was fast on Aug. 14, 8m 46s and losing 3s.6 daily. Lat. at noon was 28° 32′ S. Ship ran from sight to noon 218° (true) 48 miles. Required position at sight and noon?

Chron.	13h 28m 16s			Interval 50.5 days	
Fast	− 8m 46s			D. R. 3s.6 × 50.5 = 182s	
	13h 19m 30s			Acc. Rate losing 3m 2s	
Acc. Rate	+ 3m 2s				
G. C. T. 3d	13h 22m 32s			Dec. 3d 12h	3° 59′.8
Eq. Time	+ 10m 59s			Corr. for 1.4h	+ 1′.4
G. A. T. 3d	13h 33m 31s			Dec. 3d 13.4h	4° 1′.2 S
					−90° 0′.0
Obs. Alt.	28° 46′ 0″			P. D.	85° 58′.8
Corr. (46)	+ 9′ 8″				
h	28° 55′ 8″			Lat. Noon	28° 32′ 0″ S
Lat.	27° 54′ 12″	Sec	.05367	Diff. Lat.	37′ 48″ N
P. D.	85° 58′ 48″	Csc	.00107		
	2)142° 48′ 8″			Lat. Sight	27° 54′ 12″ S
s	71° 24′ 4″	Cos	9.50371	At Mid. Lat. 28°; Dep.	
s − h	42° 28′ 56″	Sin	9.82954	29.6 = Diff. Long. 33′.5 W	
		Log. Hav.	9.38799		

L. A. T. 3d	8h 3m 0s		
G. A. T. 3d	13h 33m 31s		
Long. at Sight	5h 30m 31s	or	82° 37′ 45″ W
Diff. Long.			33′ 30″ W
Long. at Noon			83° 11′ 15″ W

CHAPTER XX

DEVIATION BY TIME AZIMUTH OF SUN

This problem is to find the error and deviation of the compass by bearings of the sun.

Azimuth is the true bearing of a heavenly body, and is reckoned from the north point in north latitude, and from the south point in south latitude from 0° to 180°.

For example: If in north latitude and the sun bore by compass N 80° E the compass azimuth or bearing would read N 80° E, if it bore S 80° E, the azimuth would be N 100° E.

The azimuth is obtained by various instruments. The azimuth mirror in the center of the compass card being the best. The other instruments are the shadow pin; and sight vanes used in the center of the card, and the pelorus, a dummy compass with sight vanes attached. The great advantage of the azimuth mirror is that it is not necessary for the helmsman to be exactly on the course when the bearing is taken. In using the pelorus it is necessary to be on the course when taking the bearing. Due to difficulty of reading caused by rolling, pitching, etc., several readings should be taken and the average used.

Since the azimuth is changing rapidly close to noon, azimuth of the sun should be taken in the morning or evening when azimuth is changing slowly.

RULE:

1. Find G. C. T. and date.
2. Take out declination for G. C. T. and date to nearest degree.
3. Find Greenwich Apparent Time by applying equation of time to G. C. T.
4. Apply to G. A. T. the longitude in time as follows:
   Longitude West, subtract.
   Longitude East, add.
   Result will be Local Apparent Time (L. A. T.).

5. If L. A. T. is less than 12 hours, call it A. M. If more than 12 hours, subtract 12 hours, and call it P. M.
6. With Lat. and Dec. to nearest degree, and L. A. T. (A. M. or P. M.), enter Cugle's Two Minute Azimuth Tables and take out true bearing.
7. Under true bearing place compass bearing, and subtract less from greater; result will be error of compass.
8. Name the compass error as follows:
   If true bearing is to the right of compass bearing, the error is east.
   If true bearing is to the left of compass, the error is west.
   NOTE.—Always imagine that you are standing in the center of the compass and looking towards the bearings.
9. Under compass error place variation, and apply as follows:
   Variation and error same name, subtract less from greater.
   Variation and error different names, add the two.
   Result will be the deviation of the compass.
10. Name the deviation as follows:
    The deviation will always be the same name as the error, unless you subtract the error from the variation; it will then be named the opposite name to error.

PROBLEM NO. 1

July 5, 1936. A. M. at ship. Chron. read 11h 16m 30s A. M. (correct). Lat. 18° S. Long. 62° 10′ W. Sun bore by compass S 110° E. Variation 6° E. Required error and deviation of compass?

G. C. T. 5d	11h 16m 30s	Lat. 18° S (Contrary	
Eq. Time	− 4m 22s	Dec. 23° N names)	
G. A. T.	11h 12m 8s		
Long.	− 4h 8m 40s	Sun's True Bearing	S 116° 52′ E
		Sun's Comp. Bearing	S 110° 0′ E
L. A. T.	7h 3m 28s or		
	7h 3m A. M.	Error of Compass	6° 52′ W
		Variation	6° E
		Deviation	12° 52′ W

PROBLEM NO. 2

Oct. 24, 1936. A. M. at ship. Lat. 40° N. Long. 91° 2′ E. Chron. read 3h 23m 30s A. M. Sun bore by compass N 135° E. Variation 15° E. Required error and deviation of compass?

G. C. T. 24d	3h 23m 30s	Lat. 40° N (Contrary	
Eq. Time	+ 15m 43s	Dec. 12° S names)	
G. A. T.	3h 39m 13s		
Long.	+ 6h 4m 8s	Sun's True Bearing	N 140° 58′ E
		Sun's Comp. Bearing	N 135° 0′ E
L. A. T.	9h 43m 21s or		
	9h 43m A. M.	Error of Compass	5° 58′ E
		Variation	15° 0′ E
		Deviation	9° 2′ W

PROBLEM NO. 3

Jan. 30, 1936. A. M. at ship. Lat. 28° N. Long. 91° 15′ W. Chron. read 1h 50m P. M. Sun bore by compass N 126° E. Variation 7° E. Required error and deviation of compass?

G. C. T. 30d	13h 50m 0s	Lat. 28° N (Contrary	
Eq. Time	− 13m 19s	Dec. 18° S names)	
G. A. T.	13h 36m 41s		
Long.	− 6h 5m 0s	Sun's True Bearing	N 117° 4′ E
		Sun's Comp. Bearing	N 126° 0′ E
L. A. T.	7h 31m 41s or		
	7h 32m A. M.	Error of Compass	8° 56′ W
		Variation	7° 0′ E
		Deviation	15° 56′ W

PROBLEM NO. 4

April 19, 1936. A. M. at ship. Lat. 36° N. Long. 110° 25′ E. Chron. read 1h 2m A. M. Sun bore by compass N 103° E. Variation 6° E. Required error and deviation of compass?

G. C. T. 19d	1h 2m 0s	Lat. 36° N (Same	
Eq. Time	+ 46s	Dec. 11° N names)	
G. A. T.	1h 2m 46s		
Long.	+ 7h 21m 40s	Sun's True Bearing	N 103° 6′ E
		Sun's Comp. Bearing	N 103° 0′ E
L. A. T.	8h 24m 26s or		
	8h 24m A. M.	Error of Compass	0° 6′ E
		Variation	6° 0′ E
		Deviation	5° 54′ W

PROBLEM NO. 5

May 28, 1936. A. M. at ship. Lat. 27° 38′ N. Long. 127° 32′ W. Chron. read 4h 17m 20s P. M. Sun bore by compass N 87° 30′ E. Variation 9° 30′ W. Required error and deviation of compass?

G. C. T. 28d	16h 17m 20s	Lat. 28° N	(Same
Eq. Time	+ 2m 52s	Dec. 22° N	names)
G. A. T.	16h 20m 12s		
Long.	− 8h 30m 8s	Sun's True Bearing	N 81° 2′ E
		Sun's Comp. Bearing	N 87° 30′ E
L. A. T.	7h 50m 4s or		
	7h 50m A. M.	Error of Compass	6° 28′ W
		Variation	9° 30′ W
		Deviation	3° 2′ E

PROBLEM NO. 6

Feb. 11, 1936. P. M. at ship. Lat. 32° 47′ S. Long. 87° 49′ E. Chron. read 10h 23m 10s A. M., which was slow 3m 14s. Sun bore by compass S 81° 45′ W. Variation 6° E. Required error and deviation of compass?

Chron.	10h 23m 10s	Lat. 33° S	(Same
Slow	+ 3m 14s	Dec. 14° S	names)
G. C. T. 11d	10h 26m 24s		
Eq. Time	− 14m 23s	Sun's True Bearing	S 93° 44′ W
		Sun's Comp. Bearing	S 81° 45′ W
G. A. T.	10h 12m 1s		
Long.	+ 5h 51m 16s	Error of Compass	11° 59′ E
		Variation	6° 0′ E
L. A. T.	16h 3m 17s or		
	4h 3m P. M.	Deviation	5° 59′ E

PROBLEM NO. 7

Jan. 18, 1936. A. M. at ship. Lat. 43° 16′ N. Long. 37° 43′ W. Chron. read 10h 23m 10s A. M., which was fast 2m 8s. Sun bore by compass N 114° 30′E. Variation 14° E. Required error and deviation of compass?

Chron.	10h 23m 10s	Lat. 43° N	(Contrary
Fast	− 2m 8s	Dec. 21° S	names)
G. C. T. 18d	10h 21m 2s		
Eq. Time	− 10m 14s	Sun's True Bearing	N 122° 7′ E
		Sun's Comp. Bearing	N 114° 30′ E
G. A. T.	10h 10m 48s		
Long.	− 2h 30m 52s	Error of Compass	7° 37′ E
		Variation	14° 0′ E
L. A. T.	7h 39m 56s or		
	7h 40m A. M.	Deviation	6° 23′ W

PROBLEM NO. 8

Aug. 17, 1936. P. M. at ship. Lat. 29° 49′ S. Long. 109° 33′ E. Chron. read 9h 16m 28s A. M., which was slow 4m 26s. Sun bore by compass S 119° 45′ W. Variation 3° E. Required error and deviation of the compass?

Chron.		9h 16m 28s	Lat. 30° S (Contrary		
Slow	+	4m 26s	Dec. 14° N names)		
G. C. T. 17d		9h 20m 54s			
Eq. Time	−	3m 59s	Sun's True Bearing	S	113° 5′ W
			Sun's Comp. Bearing	S	119° 45′ W
G. A. T.		9h 16m 55s			
Long.	+	7h 18m 12s	Error of Compass		6° 40′ W
			Variation		3° 0′ E
L. A. T.		16h 35m 7s or			
		4h 35m P. M.	Deviation		9° 40′ W

PROBLEM NO. 9

Nov. 8, 1936. A. M. at ship. Lat. 29° 18′ S. Long. 163° 43′ E. Chron. read Nov. 7, 8h 23m 40s P. M., which was fast 8m 46s. Sun bore by compass S 94° E. Variation 1° 45′ W. Required error and deviation of compass?

Chron.		20h 23m 40s	Lat. 29° S (Same		
Fast	−	8m 46s	Dec. 16° S names)		
G. C. T. 7d		20h 14m 54s			
Eq. Time	+	16m 15s	Sun's True Bearing	S	85° 30′ E
			Sun's Comp. Bearing	S	94° 0′ E
G. A. T.		20h 31m 9s			
Long.	+	10h 54m 52s	Error of Compass		8° 30′ E
			Variation		1° 45′ W
L. A. T. 7d		31h 26m 1s			
8d		7h 26m A. M.	Deviation		10° 15′ E

PROBLEM NO. 10

Dec. 13, 1936. P. M. at ship. Lat. 36° 42′ N. Long. 154° 23′ W. Chron. read 14d 2h 18m 23s, which was slow 5m 38s. Sun bore by compass N 115° 45′ W. Variation 12° 30′ W. Required error and deviation of compass?

Chron.		2h 18m 23s	Lat. 37° N		
Slow	+	5m 38s	Dec. 23° S		
G. C. T. 14d		2h 24m 1s			
Eq. Time	+	5m 27s	Sun's True Bearing	N	124° 30′ W
			Sun's Comp. Bearing	N	115° 45′ W
G. A. T. 14d		2h 29m 28s			
Long.	−	10h 17m 32s	Error of Compass		8° 45′ W
			Variation		12° 30′ W
L. A. T. 13d		16h 11m 56s or			
		4h 12m P. M.	Deviation		3° ′ 45E

PROBLEM NO. 11

March 3, 1936. A. M. at ship. Lat. 52° 16′ N. Long. 78° 13′ W. Chron. read 2h 49m 30s P. M., which was fast 4m 36s. Sun bore by compass N 130° E. Variation 9° E. Required error and deviation of compass?

Chron.	14h 49m 30s		Lat. 52° N	
Fast	− 4m 36s		Dec. 7° S	
G. C. T. 3d	14h 44m 54s			
Eq. Time	− 12m 4s	Sun's True Bearing	N	136° 35′ E
		Sun's Comp. Bearing	N	130° 0′ E
G. A. T.	14h 32m 50s			
Long.	− 5h 12m 52s	Error of Compass		6° 35′ E
		Variation		9° 0′ E
L. A. T.	9h 19m 58s or			
	9h 20m A. M.	Deviation		2° 25′ W

PROBLEM NO. 12

July 12, 1936. P. M. at ship. Lat. 27° 18′ S. Long. 49° 38′ E. Chron. read 1h 27m 40s P. M., which was fast 18m 6s. Sun bore by compass S 125° W. Variation 9° 45′ W. Required error and deviation of compass?

Chron.	13h 27m 40s		Lat. 27° S	
Fast	− 18m 6s		Dec. 22° N	
G. C. T. 12d	13h 9m 34s			
Eq. Time	− 5m 26s	Sun's True Bearing	S	120° 56′ W
		Sun's Comp. Bearing	S	125° 0′ W
G. A. T.	13h 4m 8s			
Long.	+ 3h 18m 32s	Error of Compass		4° 4′ W
		Variation		9° 45′ W
L. A. T.	16h 22m 40s or			
	4h 23m P. M.	Deviation		5° 41′ E

CHAPTER XXI

DEVIATION BY AMPLITUDE OF SUN

An amplitude is the bearing of a heavenly body at rising or setting.

It is reckoned from the east and west points of the compass towards north and south from 0° to 90°.

To convert a compass bearing into an amplitude proceed as follows:

If the sun bore at rising N 82° E, the compass amplitude would be E 8° N.

If the sun bore at setting S 79° W, the compass amplitude would be W 11° S.

RULE:

1. Find G. C. T. and date.
2. Take out sun's declination for G. C. T. and date to nearest minute of declination.
3. From Table 44 (Bowditch) take out the following:
   Log. Secant of latitude, rejecting 10 from index number.
   Log. Sine of declination.
   Add these two logs. together.
4. Log. Sine that agrees with sum of logs. will be true amplitude.
5. Name true amplitude as follows:
   If sun is rising, E. If setting, W.
   If declination is North, name N. If South, name S.
6. Convert compass bearing into an amplitude, and apply it to true amplitude as follows:
   If both are of same name, subtract less from greater.
   If different names, add the two.
   Result will be error of compass.
7. Name error of compass as follows:
   If true amplitude is to left of compass amplitude, the error is west.
   If true is to right of compass, error is east.

8. Under error put down variation, and apply as follows:
   Same names, subtract less from greater.
   Contrary names, add.
   Result will be deviation.
9. Name the deviation as follows:
   The deviation will always be named the same as the error, unless you subtract the error from the variation, it will then be named the opposite to error.

Table 39 (Bowditch) may also be used to find true amplitude. Most local inspectors, however, insist that the amplitude be worked out.

PROBLEM NO. 1

Jan. 30, 1936. Sun bore at rising N 83° E. Chron. read 2h 12m P. M. Lat. 46° 15′ S. Variation 8° E. Required error and deviation of compass?

G. C. T. 30d 14h 12m Dec. 30d 14.2h 17° 52′ S

Sec. of Lat.	.16020		
Sin of Dec.	9.48686		
Sin	9.64706	= True Amp.	E 26° 20′ S
		Comp. Amp.	E 7° 0′ N
		Comp. Error	33° 20′ E
		Variation	8° 0′ E
		Deviation	25° 20′ E

PROBLEM NO. 2

Oct. 22, 1936. Sun bore at rising S 71° E. Chron. read 1h 50m P. M. Lat. 43° 2′ N. Variation 25° W. Required error and deviation of compass?

G. C. T. 22d 13h 50m Dec. 11° 7′ S

Sec. of Lat.	.13611		
Sin of Dec.	9.28512		
Sin	9.42123	= True Amp.	E 15° 18′ S
		Comp. Amp.	E 19° 0′ S
		Comp. Error	3° 42′ W
		Variation	25° 0′ W
		Deviation	21° 18′ E

PROBLEM NO. 3

April 19, 1936. Sun bore at setting S 82° W. Chron. read 9h 15m A. M. Lat. 40° 12′ N. Variation 6° E. Required error and deviation of compass?

G. C. T. 19d 9h 15m Dec. 11° 10′ N

Sec. of Lat.	.11702		
Sin of Dec.	9.28705		
Sin	9.40407 =	True Amp.	W 14° 41′ N
		Comp. Amp.	W 8° 0′ S
		Comp. Error	22° 41′ E
		Variation	6° 0′ E
		Deviation	16° 41′ E

PROBLEM NO. 4

March 11, 1936. Sun bore at rising S 88° E. Chron. read 8h 15m A. M. Lat. 0° 10′ N. Variation 15° E. Required error and deviation of compass?

G. C. T. 11d 8h 15m Dec. 3° 43′ S

Dec. = True Amp. in Lat. 0°

True Amp.	E	3° 43′ S
Comp. Amp.	E	2° 0′ S
Comp. Error		1° 43′ E
Variation		15° 0′ E
Deviation		13° 17′ W

PROBLEM NO. 5

Sept. 23, 1936. Sun bore at setting N 79° W. Chron. read 2h 10m P. M. Lat. 48° N. Variation 2° W. Required error and deviation?

G. C. T. 23d 14h 10m Dec. 0°

True Amp. is E or W or 0° in Dec. 0°

True Amp.	W	0° 0′
Comp. Amp.	W	11° 0′ N.
Comp. Error		11° 0′ W
Variation		2° 0′ W
Deviation		9° 0′ W

PROBLEM NO. 6

Aug. 11, 1936. Sun bore at setting S 81° W. Chron. read 10h 28m A. M., which was slow 32m. Lat. 18° 28′ S. Variation 30° E. Required error and deviation of compass?

Chron. 10h 28m — Dec. 15° 16′ N
Slow + 32m

G. C. T. 11d 11h 0m

Sec. of Lat.	.02296		
Sin of Dec.	9.42047		
Sin	9.44343 =	True Amp.	W 16° 7′ N
		Comp. Amp.	W 9° 0′ S
		Comp. Error	25° 7′ E
		Variation	30° 0′ E
		Deviation	4° 53′ W

PROBLEM NO. 7

Jan. 31, 1936. Sun bore at rising S 84° E. Chron. read 4h 16m P. M. Lat. 36° 18′ N. Variation 3° W. Required error and deviation?

G. C. T. 31d 16h 16m — Dec. 17° 34′ S

Sec. of Lat.	.09370		
Sin of Dec.	9.47974		
Sin	9.57344 =	True Amp.	E 22° 0′ S
		Comp. Amp.	E 6° 0′ S
		Comp. Error	16° 0′ E
		Variation	3° 0′ W
		Deviation	19° 0′ E

PROBLEM NO. 8

July 4, 1936. Sun bore at setting S 84° W. Chron. read 11h 58m P. M. Lat. 36° 18′ N. Variation 10° W. Required error and deviation?

G. C. T. 4d 23h 58m — Dec. 22° 50′ N

Sec. of Lat.	.09370		
Sin of Dec.	9.58889		
Sin	9.68259 =	True Amp.	W 28° 47′ N
		Comp. Amp.	W 6° 0′ S
		Comp. Error	34° 47′ E
		Variation	10° 0′ W
		Deviation	44° 47′ E

PROBLEM NO. 9

Dec. 16, 1936. Sun bore at rising S 60° E. Chron. read 2h 12m P. M. Lat. 0° 18′ S. Variation 16° W. Required error and deviation?

G. C. T. 16d 14h 12m

Dec. 23° 20′ S

True Amp.	E 23° 20′ S
Comp. Amp.	E 30° 0′ S
Comp. Error	6° 40′ W
Variation	10° 0′ W
Deviation	3° 20′ E

PROBLEM NO. 10

March 21, 1936. Sun bore at setting N 78° W. Chron. read 10h 6m P. M. Lat. 0° 14′ N. Variation 3° E. Required error and deviation?

G. C. T. 21d 22h 6m

Dec. 0° 27′ N

True Amp.	W 0° 27′ N
Comp. Amp.	W 12° 0′ N
Comp. Error	11° 33′ W
Variation	3° 0′ E
Deviation	14° 33′ W

PROBLEM NO. 11

Jan. 31, 1936. Sun bore at rising N 89° E. Chron. read 1h 50m A. M. Lat. 41° 21′ N. Variation 35° E. Required error and deviation?

G. C. T. 31d 1h 50m

Dec. 17° 44′ S

Sec. of Lat.	.12454		
Sin of Dec.	9.48371		
Sin	9.60825	= True Amp.	E 23° 56′ S
		Comp. Amp.	E 1° 0′ N
		Comp. Error	24° 56′ E
		Variation	35° 0′ E
		Deviation	10° 4′ W

PROBLEM NO. 12

Oct. 23, 1936. Sun bore at setting S 88° W. Chron. read 2h 10m P. M. Lat. 18° 24′ N. Variation 3° E. Required error and deviation?

G. C. T. 23d 14h 10m Dec. 11° 29′ S

Sec. of Lat.	.02279		
Sin of Dec.	9.29903		
Sin	9.32182	= True Amp.	W 12° 7′ S
		Comp. Amp.	W 2° 0′ S
		Comp. Error	10° 7′ W
		Variation	3° 0′ E
		Deviation	13° 7′ W

CHAPTER XXII

LATITUDE BY POLARIS
(Siderial Time Method)

The latitude by polaris (or north star) can be obtained at any time the star is visible, as long as the sea horizon is clear enough to obtain a proper altitude.

If the North Star were exactly at the pole, its altitude would be the latitude. It is, however, not quite at the pole; so that it apparently describes a small circle in the sky about the pole as an axis. This makes necessary a correction to the true altitude. These corrections are given in the Nautical Almanac, Table 1, for every ten minutes Local Siderial Time.

There are two methods used in solving this problem. One known as Siderial Time Method, explained in this chapter, and the other as Hour Angle Method, explained in Chapter XXIII.

RULE:

1. Find G. C. T. and date.
2. From pages 2–3 (N. A.) take out Siderial Time of 0h Civil Time at Greenwich (R. A. M. S. +12h) for the Greenwich date, and from the table below (correction for longitude from Greenwich) take out the correction for the G. C. T.
3. Add together the above three quantities. That is, G. C. T., Sid. T. of 0h C. T., and correction from table below.
   Result will be Greenwich Siderial Time (G. S. T.).
4. Apply to G. S. T. the longitude in time as follows:
   Longitude West, subtract from G. S. T.
   Longitude East, add.
   Result will be Local Siderial Time (L. S. T.).
5. Correct the observed altitude of polaris for I. E. (if any); Dip, and refraction, or take the total correction from Table 46 (Bowditch).
   Result will be True Altitude (h).

6. From Table 1 (N. A.), page 262, take out the correction for the true altitude by using the L. S. T. and apply correction as by sign given in N. A. Result will be latitude, always north.

As the correction in Table 1 is only given for every ten minutes of L. S. T., it is necessary to interpolate when the minutes of time are odd.

PROBLEM NO. 1

Jan. 31, 1936. A. M. at ship. Obs. Alt. *Polaris 24° 55′. Dip 36 ft. Chron. read 0h 22m P. M. Long. 93° 30′ W. Required Lat.?

G. C. T. 31d	12h 22m 0s	Obs. Alt.	24° 55′ 0″ N
S. T. of 0h G. C. T.	8h 36m 12s	Corr. (46)	− 7′ 58″
Corr. 12h 22m	2m 2s		
		h	24° 47′ 2″
G. S. T.	21h 0m 14s	Corr. (I)	+ 0° 59′ 42″
Long.	− 6h 14m 0s		
		Lat.	25° 46′ 44′ N
L. S. T.	14h 46m 14s		

Table I (N. A.) for L. S. T. 14h 40m = Corr. 1° 0′.1
Diff. between 14h 40m and 14h 50m = 7
If change is 7 in 10m it will be .7 in 1m
Therefore .7 × 6m = .42
And 1° 0′.1
− .4 (Corr. decreasing)

0° 59′.7 is the correction for 14h 46m

PROBLEM NO. 2

Jan. 30, 1936. Obs. Alt. *Polaris 27° 27′. Dip 36 ft. Chron. read 0h 17m P. M. Long. 90° W. Required Lat.?

G. C. T. 30d	12h 17m 0s	Obs. Alt.	27° 27′ 0″
S. T. of 0h C. T.	8h 32m 15s	Corr. (46)	7′ 45″
Corr. 12h 17m	2m 1s		
		h	27° 19′ 15″
G. S. T.	20h 51m 16s	Corr. (I)	+ 59′ 18″
Long.	− 6h 0m 0s		
		Lat.	28° 18′ 33″ N
L. S. T.	14h 51m 16s		

PROBLEM NO. 3

July 15, 1936. Obs. Alt. *Polaris 26° 17′. Dip 20 ft. Chron. read 1h 15m 21s P. M. Long. 82° 17′ E. Required Lat.?

G. C. T. 15d	13h 15m 21s	Obs. Alt.	26° 17′ 0″
S. T. of 0h C. T.	19h 30m 40s	Corr. (46)	− 6′ 20″
Corr. 13h 15m	2m 11s		
		h	26° 10′ 40″
G. S. T.	32h 48m 12s	Corr. (I)	+ 1° 1′ 18″
Long.	+ 5h 29m 8s		
	38h 17m 20s	Lat.	27° 11′ 58″ N
	−24h 0m 0s		
L. S. T.	14h 17m 20s		

PROBLEM NO. 4

Nov. 10, 1936. Obs. Alt. *Polaris 36° 21′. Dip 17 ft. Chron. read 11h 15m 20s A. M. Long. 98° 22′ W. Required Lat.?

G. C. T. 10d	11h 15m 20s	Obs. Alt.	36° 21′ 0″
S. T. of 0h C. T.	3h 15m 53s	Corr. (46)	− 5′ 21″
Corr. 11h 15m	1m 51s		
		h	36° 15′ 39″
G. S. T.	14h 33m 4s	Corr. (I)	+ 5′ 48″
Long.	− 6h 33m 28s		
		Lat.	36° 21′ 27″ N
L. S. T.	7h 59m 36s		

PROBLEM NO. 5

Aug. 6, 1936. Obs. Alt. *Polaris 28° 16′. Dip 23 ft. Chron. read 2h 16m 28s A. M., which was slow 1m 25s. Long. 38° 21′ E. Required Lat.?

Chron.	2h 16m 28s	Obs. Alt.	28° 16′ 0″
Slow	+ 1m 25s	Corr. (46)	− 6′ 30″
G. C. T. 6d	2h 17m 53s	h	28° 9′ 30″
S. T. 0h G. C. T.	20h 57m 24s	Corr. (I)	− 1° 2′ 6″
Corr. 2h 18m	23s		
		Lat.	27° 7′ 24″ N
G. S. T.	23h 15m 40s		
Long.	+ 2h 33m 24s		
	25h 49m 4s		
	−24h 0m 0s		
L. S. T.	1h 49m 4s		

PROBLEM NO. 6

June 8, 1936. Obs. Alt. *Polaris 23° 12′ 15″. Dip 38 ft. Chron. read 11h 55m 25s A. M. Long. 110° 15′ W. Required Lat.?

G. C. T. 8d	11h 55m 25s	Obs. Alt.	23° 12′ 15″
S. T. of 0h G. C. T.	17h 4m 47s	Corr. (46)	− 8′ 17″
Corr. 11h 55m	1m 58s		
		h	23° 3′ 58″
G. S. T.	29h 2m 10s	Corr. (I)	− 30′ 48″
Long.	− 7h 21m 0s		
		Lat.	22° 33′ 10″ N
L. S. T.	21h 41m 10s		

PROBLEM NO. 7

Oct. 6, 1936. A. M. Obs. Alt. *Polaris 50° 24′ 45″. Dip 40 ft. Chron. read 9h 22m 3s A. M., which was slow 4m 23s. Long. 18° 16′ W. Required Lat.?

Chron.	9h 22m 3s	Obs. Alt.	50° 24′ 45″
Slow	+ 4m 23s	Corr. (46)	− 7′ 0″
G. C. T. 6d	9h 26m 26s	h	50° 17′ 45″
S. T. 0h G. C. T.	0h 57m 54s	Corr. (I)	+ 24′ 48″
Corr. 9h 26m	1m 33s		
		Lat.	50° 42′ 33″ N
G. S. T.	10h 25m 53s		
Long.	− 1h 13m 4s		
L. S. T.	9h 12m 49s		

PROBLEM NO. 8

May 20, 1936. Obs. Alt. *Polaris 42° 16′ 30″. Dip 39 ft. Chron. read 6h 16m 23s P. M., which was fast 3m 18s. Long. 3° 15′ E. Required Lat.?

Chron.	18h 16m 23s	Obs. Alt.	42° 16′ 30″
Fast	− 3m 18s	Corr. (46)	− 7′ 12″
G. C. T. 20d	18h 13m 5s	h	42° 9′ 18″
S. T. 0h G. C. T.	15h 49m 53s	Corr. (I)	+ 40′ 0″
Corr. 18h 13m	3m 0s		
		Lat.	42° 49′ 18″ N
G. S. T.	34h 5m 58s		
Long.	+ 13m		
	34h 18m 58s		
L. S. T.	10h 18m 58s		

PROBLEM NO. 9

Feb. 12, 1936. Obs. Alt. *Polaris 48° 16′. Dip 21 ft. Chron. read 2h 6m 28s P. M. Long. 152° W. Required Lat.?

G. C. T. 12d	14h 6m 28s	Obs. Alt.	48° 16′ 0″
S. T. 0h G. C. T.	9h 23m 30s	Corr. (46)	− 5′ 21″
Corr. 14h 6m	2m 19s		
			48° 10′ 39″
G. S. T.	23h 32m 17s	Corr. (I)	+ 1° 2′ 0″
Long.	−10h 8m 0s		
		Lat.	49° 12′ 39″ N
L. S. T.	13h 24m 17s		

PROBLEM NO. 10

June 6, 1936. Obs. Alt. *Polaris 29° 41′. Dip 20 ft. Chron. read 8h 16m 21s A. M. Long. 161° 15′ E. Required Lat.?

G. C. T. 6d	8h 16m 21s	Obs. Alt.	29° 41′ 0″
S. T. 0h G. C. T.	16h 56m 54s	Corr. (46)	− 6′ 5″
Corr. 8h 16m	1m 21s		
		h	29° 34′ 55″
G. S. T.	25h 14m 36s	Corr. (I)	+ 56′ 24″
Long.	+10h 45m 0s		
		Lat.	30° 31′ 19″ N
	35h 59m 36s		
L. S. T.	11h 59m 36s		

PROBLEM NO. 11

Oct. 25, 1936. Obs. Alt. *Polaris 47° 15′. Dip 26 ft. Chron. read 1h 16m 28s P. M. Long. 100° W. Required Lat.?

G. C. T. 25d	13h 16m 28s	Obs. Alt.	47° 15′ 0″
S. T. 0h G. C. T.	2h 12m 48s	Corr. (46)	− 5′ 54″
Corr. 13h 16m	2m 11s		
		h	47° 9′ 6″
G. S. T.	15h 31m 27s	Corr. (I)	+ 19′ 18″
Long.	− 6h 40m 0s		
		Lat.	47° 28′ 24″ N
L. S. T.	8h 51m 27s		

PROBLEM NO. 12

July 4, 1936. Obs. Alt. *Polaris 28° 32′. Dip 27 ft. Chron. read 10h 58m 3s A. M. Long. 94° 50′ W. Required Lat.?

G. C. T. 4d	10h 58m 3s	Obs. Alt.	28° 32′ 0″
S. T. 0h G. C. T.	18h 47m 18s	Corr. (46)	− 6′ 53″
Corr. 10h 58m	1m 48s		
		h	28° 25′ 7″
G. S. T.	29h 47m 9s	Corr. (I)	− 51′ 54″
Long.	− 6h 19m 20s		
		Lat.	27° 33′ 13″ N
L. S. T.	23h 27m 49s		

CHAPTER XXIII

LATITUDE BY POLARIS

(Hour Angle Method)

RULE:

1. Find Greenwich Civil Time (G. C. T.) and date.

2. From page 261 (N. A.) take out Greenwich Hour Angle (G. H. A.) for 0h G. C. T. using Greenwich date.

3. From pages 210–212 (N. A.) take out correction for G. C. T. of example. This is always to be added to G. H. A. 0h. Result will be G. H. A. for G. C. T.

4. If Longitude is West subtract longitude in degrees from G. H. A. for G. C. T.; if East Longitude add. Result will be local Hour Angle (L. H. A.) of Polaris.

   Note: If Longitude in degrees is greater than the G. H. A. for G. C. T. in degrees, and the longitude is West, add 360° to G. H. A. for G. C. T.

   If L. H. A. of Polaris exceeds 360°, subtract 360° from it. Result will be L. H. A. of Polaris.

5. Correct the observed altitude of Polaris for I. E. (if any); dip and refraction, or take the total correction from Table 46 (Bowditch).

   Result will be True Altitude (h).

6. From Table 1 (page 265 N. A.) take out the correction for true altitude by using the L. H. A. of Polaris, and apply correction as by sign given in N. A.

   Result will be latitude, always north.

PROBLEM NO. 1

Jan. 31, 1936. A. M. at ship. Obs. Alt. *Polaris 24° 55′. Dip 36 ft. Chron. read 0h 22m P. M. Long. 93° 30′ W. Required Lat.?

G. C. T. Jan. 31d 12h 22m 0s

Page 261 (N. A.)			
Jan. 31d G. H. A. 0h	=104° 1′.0	Obs. Alt.	24° 55′ 0″ N
Pages 210–212 (N. A.)			
G. C. T. 12h 22m	=186° 0′.5+	Corr. (46) −	7′ 58″
G. H. A. for G. C. T.	290° 1′.5	h	24° 47′ 2″
Longitude West	− 93° 30′.0	Corr. I +	59′ 42″ †
L. H. A. of Polaris	196° 31′.5	Lat.	25° 46′ 44″ N

(† Page 265 N. A.)

PROBLEM NO. 2

Jan. 30, 1936. Obs. alt. *Polaris 27° 27′. Dip 36 ft. Chron. read 0h 17m P. M. Long. 90° W. Required Lat.?

G. C. T. Jan. 30d 12h 17m 0s

Jan. 30d G. H. A. 0h	=103° 1′.6	Obs. Alt.	27° 27′ 0″
G. C. T. 12h 17m	=184° 45′.3+	Corr. (46) −	7′ 45″
G. H. A. for G. C. T.	287° 46′.9	h	27° 19′ 15″
Long. West	− 90° 0′.0	Corr. I +	59′ 18″
L. H. A. Polaris	197° 46′.9	Lat.	28° 18′ 33″ N

PROBLEM NO. 3

July 15, 1936. Obs. Alt. *Polaris 26° 17′. Dip 20 ft. Chron. read 1h 15m 21s P. M. Long. 82° 17′ E. Required Lat.?

G. C. T. July 15d 13h 15m 21s

July 15d G. H. A. 0h	= 267° 30′.2	Obs. Alt.	26° 17′ 0″
G. C. T. 13h 15m 21s	=+199° 22′.9	Corr. (46) −	6′ 20″
G. H. A. for G. C. T.	466° 53′.1	h	26° 10′ 40″
Long. East	+ 82° 17′.0	Corr. I +	1° 1′ 24″
	549° 10′.1	Lat.	27° 12′ 4″ N
	−360° 0′.0		
L. H. A. Polaris	189° 10′.1		

PROBLEM NO. 4

Nov. 10, 1936. Obs. Alt. *Polaris 36° 21′. Dip 17 ft. Chron. read 11h 15m 20s A. M. Long. 98° 22′ W. Required Lat.?

G. C. T. Nov. 10d 11h 15m 20s

Nov. 10d G. H. A. 0h	= 23° 27′.6	Obs. Alt.	36° 21′ 0″
G. C. T. 11h 15m 20s	= +169° 17′.7	Corr. (46)	− 5′ 21″
G. H. A. for G. C. T.	192° 45′.3	h	36° 15′ 39″
Long. West	− 98° 22′.0	Corr. I	+ 5′ 24″
L. H. A. Polaris	94° 23′.3	Lat.	36° 21′ 3″ N

PROBLEM NO. 5

Aug. 6, 1936. Obs. Alt. *Polaris 28° 16′. Dip 23 ft. Chron. read 2h 16m 28s A. M., which was slow 1m 25s. Long. 38° 21′ E. Required Lat.?

Chron.	2h 16m 28s		
Slow	+ 1m 25s		
G. C. T. 6d	2h 17m 53s		
Aug. 6d G. H. A. 0h	= 289° 4′.5	Obs. Alt.	28° 16′ 0″
G. C. T. 2h 17m 53s	= + 34° 33′.9	Corr. (46)	− 6′ 30″
G. H. A. for G. C. T.	323° 38′.4	h	28° 9′ 30″
Long. East	+ 38° 21′.0	Corr. I	− 1° 2′ 6″
	361° 59′.4	Lat.	27° 7′ 24″ N
	−360° 0′.0		
L. H. A. Polaris	1° 59′.4		

PROBLEM NO. 6

June 8, 1936. Obs. Alt. *Polaris 23° 12′ 15″. Dip 38 ft. Chron. read 11h 55m 25s A. M. Long. 110° 15′ W. Required Lat.?

G. C. T. 8d 11h 55m 25s

June 8d G. H. A. 0h	= 231° 13′.1	Obs. Alt.	23° 12′ 15″
G. C. T. 11h 55m 25s	= +179° 20′.7	Corr. (46)	− 8′ 17″
G. H. A. for G. C. T.	410° 33′.8	h	23° 3′ 58″
Long. West	−110° 15′.0	Corr. I	− 30′ 54″
L. H. A. Polaris	300° 18′.8	Lat.	22° 33′ 4″ N

PROBLEM NO. 7

Oct. 6, 1936. A. M. Obs. Alt. *Polaris 50° 24′ 45″. Dip 40 ft. Chron. read 9h 22m 3s A.M., which was slow 4m 23s. Long. 18° 16′ W. Required Lat.?

Chron.	9h 22m 3s			
Slow	+ 4m 23s			
G. C. T. 6d	9h 26m 26s			
Oct. 6d G. H. A. 0h	= 348° 58′.6	Obs. Alt.	50° 24′ 45″	
G. C. T. 9h 26m 26s	= +141° 59′.7	Corr. (46)	− 7′ 0″	
G. H. A. for G. C. T.	490° 58′.3	h	50° 17′ 45″	
Long. West	− 18° 16′.0	Corr. I	+ 24′ 30″	
	472° 42′.3	Lat.	50° 42′ 15″ N	
	−360° 0′.0			
L. H. A. Polaris	112° 42′.3			

PROBLEM NO. 8

May 20, 1936. Obs. Alt. *Polaris 42° 16′ 30″. Dip 39 ft. Chron. read 6h 16m 23s P. M., which was fast 3m 18s. Long. 3° 15′ E. Required Lat.?

Chron.	18h 16m 23s			
Fast	− 3m 18s			
G. C. T. 20d	18h 13m 5s			
May 20d G. H. A. 0h	= 212° 34′.0	Obs. Alt.	42° 16′ 30″	
G. C. T. 18h 13m 5s	= +274° 1′.2	Corr. (46)	− 7′ 12″	
G. H. A. for G. C. T.	486° 35′.2	h	42° 9′ 18″	
Long. East	+ 3° 15′.0	Corr. I	+ 40′ 6″	
	489° 50′.2	Lat.	42° 49′ 24″ N	
	−360° 0′.0			
L. H. A. Polaris	129° 50′.2			

PROBLEM NO. 9

Feb. 12, 1936. Obs. Alt. *Polaris 48° 16′. Dip 21 ft. Chron. read 2h 6m 28s P. M. Long. 152° W. Required Lat.?

G. C. T. 12d 14h 6m 28s

Feb. 12d G. H. A. 0h	= 115° 54′.0	Obs. Alt.	48° 16′ 0″	
G. C. T. 14h 6m 28s	= +212° 11′.7	Corr. (46)	− 5′ 21″	
G. H. A. for G. C. T.	328° 5′.7	h	48° 10′ 39″	
Long. West	−152° 0′.0	Corr. I	+ 1° 2′ 0″	
L. H. A. Polaris	176° 5′.7	Lat.	49° 12′ 39″ N	

PROBLEM NO. 10

June 6, 1936. Obs. Alt. *Polaris 29° 41′. Dip 20 ft. Chron. read 8h 16m 21s A. M. Long. 161° 15′ E. Required Lat.?

G. C. T. 6d 8h 16m 21s

June 6d G. H. A. 0h	= 229° 15′.4	Obs. Alt.	29° 41′ 0″
G. C. T. 8h 16m 21s	= +124° 25′.7	Corr. (46)	− 6′ 5″
G. H. A. for G. C. T.	353° 41′.1	h	29° 34′ 55″
Long. East	+161° 15′.0	Corr. I	+ 56′ 24″
	514° 56′.1	Lat.	30° 31′ 19″ N
	−360° 0′.0		
L. H. A. Polaris	154° 56′.1		

PROBLEM NO. 11

Oct. 25, 1936. Obs. Alt. *Polaris 47° 15′. Dip 26 ft. Chron. read 1h 16m 28s P. M. Long. 100° W. Required Lat.?

G. C. T. 25d 13h 16m 28s

Oct. 25d G. H. A. 0h	= 7° 41′.1	Obs. Alt.	47° 15′ 0″
G. C. T. 13h 16m 28s	= +199° 39′.7	Corr. (46)	− 5′ 54″
G. H. A. for G. C. T.	207° 20′.8	h	47° 9′ 6″
Long. West	−100° 0′.0	Corr. I	+ 19′ 6″
L. H. A. Polaris	107° 20′.8	Lat.	47° 28′ 12″ N

PROBLEM NO. 12

July 4, 1936. Obs. Alt. *Polaris 28° 32′. Dip 27 ft. Chron. read 10h 58m 3s A. M. Long. 94° 50′ W. Required Lat.?

G. C. T. 4d 10h 58m 3s

July 4d G. H. A. 0h	= 256° 43′.1	Obs. Alt.	28° 32′ 0″
G. C. T. 10h 58m 3s	= +164° 57′.8	Corr. (46)	− 6′ 53″
G. H. A. for G. C. T.	421° 40′.9	h	28° 25′ 7″
Long. West	− 94° 50′.0	Corr. I	− 51′ 54″
L. H. A. Polaris	326° 50′.9	Lat.	27° 33′ 13″ N

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EXTRACTS FROM AMERICAN NAUTICAL ALMANAC, 1936

GREENWICH HOUR ANGLE OF POLARIS, 1936, FOR 0h GREENWICH CIVIL TIME

		°	′			°	′
Jan.	28	101	2.7	July	3	255	44.3
	29	102	2.2		4	256	43.1
	30	103	1.6		5	257	42.0
	31	104	1.0		14	266	31.4
Feb.	1	105	0.4		15	267	30.2
	11	114	54.6		16	268	29.0
	12	115	54.0	Aug.	5	288	5.6
	13	116	53.4		6	289	4.5
May	19	211	35.1		7	290	3.4
	20	212	34.0	Oct.	5	347	59.6
	21	213	32.9		6	348	58.6
June	5	228	16.5		7	349	57.6
	6	229	15.4		24	6	42.0
	7	230	14.3		25	7	41.1
	8	231	13.1		26	8	40.2
	9	232	12.0	Nov.	9	22	28.4
					10	23	27.6
					11	24	26.8

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TABLE III

FOR FINDING LATITUDE FROM ALTITUDE OF POLARIS, 1936.
CORRECTION FOR LOCAL HOUR ANGLE TO BE APPLIED TO TRUE ALTITUDE

L.H.A.	Corr.		L.H.A.	Corr.	
°	°	′	°	°	′
0	−1	2.2	175	+1	1.9
1	1	2.2	176	1	2.0
2	−1	2.1	177	+1	2.1
93	+0	3.8	188	+1	1.6
94	0	4.9	189	1	1.4
95	+0	6.0	190	+1	1.2
106	+0	17.7	196	+0	59.8
107	0	18.7	197	0	59.5
108	+0	19.7	198	0	59.2
111	+0	22.8	199	+0	58.8
112	0	23.8	299	−0	29.7
113	+0	24.8	300	0	30.7
128	+0	38.6	301	−0	31.6
129	0	39.5	325	−0	50.7
130	+0	40.3	326	0	51.4
153	+0	55.5	327	−0	52.0
154	0	56.0			
155	+0	56.4			

CHAPTER XXIV

LONGITUDE BY SUN; ALTITUDE AZIMUTH; MERIDIAN ALTITUDE OF SUN AND MERCATOR SAILING COMBINED

This problem is worked the same as previous methods for obtaining latitude by sun, longitude by sun, and course and distance by Mercator's sailing.

The difference in the chronometer sights are that two rates for the chronometer are given, and it is necessary to find the daily rate.

To find daily rate of chronometer proceed as follows:

If first and second rate are both fast or both slow, subtract less from greater.

If first and second rate are one fast and one slow, add the two.

Turn this result to seconds by multiplying minutes by 60 and add to the result the seconds.

Divide number of seconds by number of days between the rates, and the result will be daily rate.

Put down chronometer time and apply to it the last rate given in example.

Find the number of days between last rate and date of example to the nearest tenth of a day, and multiply number of days and tenths by daily rate already obtained.

Result will be accumulated rate, which apply to chronometer, and the result will be G. C. T.

The latitude at noon is found if sun's meridian altitude is given, and latitude at sight found as in previous noon position sights.

Now proceed to find the longitude at sight and noon.

The altitude azimuth is worked in conjunction with a regular longitude sight, and the true bearing is obtained without the use of azimuth tables.

To find true bearing by altitude azimuth proceed as follows:

Add together true altitude, latitude and polar distance, using the same altitude, latitude and polar distance that longitude sight was worked with.

Divide sum by 2; answer will be half sum.

Under half sum put down polar distance, and subtract less from greater; result will be remainder.

From Table 44 (Bowditch) take out the following logs:

Secant of altitude; rejecting 10 from index number.

Secant of latitude; rejecting 10 from index number.

Cosine of half sum.

Cosine of remainder.

Add these four logarithms together.

Log. Haversine (Table 45) gives azimuth. Result will be true bearing from depressed pole.

If in north latitude name the true bearing S. If sight is A. M., East; P. M., West.

If in south latitude name the true bearing N. If sight is A. M., East; P. M., West.

Under true bearing put down compass bearing and obtain error and deviation of compass same as in azimuths from the tables.

The position of the ship at noon is then put down as lat. A and long. A, and the course and distance found by Mercator's sailing to position given in example.

PROBLEM NO. 1

Jan. 31, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 35° 28′ 18″. Dip 15 ft. Index error +50″. Chron. read 2h 30m 44s P. M., which was slow on Nov. 25, 10m 20s and on Dec. 11 was slow 13m 49s.

At noon the Mer. Alt. Sun's L. L. was 59° 59′ S. Long. by D. R. 87° W. Ship ran from sight to noon S 73° W (true) 48 miles.

Sun bore by compass at time of morning sight N 108° 15′ E. Var. 16° W.

Required position at sight and noon; error and deviation of compass by altitude azimuth; and course and distance by Mercator's sailing from noon to Lat. 7° 15′ S. Long. 125° 35′ W?

Obs. Mer. Alt.	59° 59′ 0″	L. A. T.	12h 0m 0s
I. E.	+ 50″	Long.	+ 5h 48m 0s
	59° 59′ 50″	G. A. T.	17h 48m 0s
Corr. (46)	+ 11′ 59″	Eq. Time	+ 13m 30s
h	60° 11′ 49″ S	G. C. T. 31d	18h 1m 30s
	90° 0′ 0″		
Z. D.	29° 48′ 11″ N	Dec. 31d 18h 17° 33′.3 S	
T. D.	17° 33′ 18″ S		
Lat. Noon	12° 14′ 53″ N	At Mid. Lat. 13°; Dep. 45.9 =	
D. Lat.	14′ 0″ N	Diff. Long. 47′ W	
Lat. Sight	12° 28′ 53″ N		

Chron.	14h 30m 44s	Chron. slow Nov. 25d 10m 20s
Slow	+ 13m 49s	slow Dec. 11d 13m 49s
	14h 44m 33s	losing in 16d 3m 29s or
Acc. Rate	+ 11m 11s	209s 209s
		——— = 13s daily rate
G. C. T. 31d	14h 55m 44s	16 days
Eq. Time	− 13m 29s	
G. A. T. 31d	14h 42m 15s	Interval 51.6 days
		D. R. 13s × 51.6 = 671s
		Acc. Rate losing 11m 11s

Dec. 31d 14h	17° 36′ .1
Corr. for .9h	− .6
Dec. 31d 14.9h	17° 35′ .5 S
	90° 0′ .0
P. D	107° 35′ .5

Obs. Alt.	35° 28′ 18″					
I. E.	+ 50″					
	35° 29′ 8″					
Corr. (46)	+ 11′ 16″					
h	35° 40′ 24″			Sec		.09026
Lat.	12° 28′ 53″	Sec	.01038	Sec		.01038
P. D.	107° 35′ 30″	Csc	.02080			
	2)155° 44′ 47″					
s	77° 52′ 23″	Cos	9.32239	Cos		9.32239
s − h	42° 11′ 59″	Sin	9.82719			
s − PD	29° 43′ 7″			Cos		9.93875
		Log. Hav.	9.18076	Log. Hav.		9.36178

L. A. T. 31d	8h 56m 40s	Sun's True Bearing	S 57° 19′ E
G. A. T. 31d	14h 42m 15s		180° 0′
Long. at Sight	5h 45m 35s or 86° 23′ 45″ W	Sun's True Bearing	N 122° 41′ E
		Sun's Comp. Bearing	N 108° 15′ E
Diff. Long.	47′ 0″ W		
		Comp. Error	14° 26′ E
Long. at Noon	87° 10′ 45″ W	Variation	16° 0′ W
		Deviation	30° 26′ E

Lat. A	12° 15′ N	Mer. Parts	735.7	Long. A	87° 11′ W
Lat. B	7° 15′ S		433.2	Long. B	125° 35′ W
Diff. Lat.	19° 30′ or 1170′		1168.9	Diff. Long.	38° 24′ or 2304′

Log. of Diff. Long. 2304 = 13.36248
Log. of M. P. 1169 = 3.06781

Tangent 10.29467 = Course S 63° 6′ W

Sec. of Course 63° 6′ = .34444
Log. of Diff. Lat. 1170 = 3.06819

Log. 3.41263 = Distance 2586 miles

Answer:

At Sight Lat. 12° 28′ 53″ N Long. 86° 23′ 45″ W
At Noon Lat. 12° 14′ 53″ N Long. 87° 10′ 45″ W
Error of compass 14° 26′ E Deviation 30° 26′ E
True Course S 63° 6′ W Distance 2586 miles.

PROBLEM NO. 2

April 23, 1936. A. M. at ship. Obs. Alt. Sun's L. L. 19° 28′. Dip 39 ft. Chron. read 4h 36m 23s P. M., which was fast on Jan 8, 28m 16s and on Feb. 26 was fast 24m 52s.

At noon the Obs. Mer. Alt. Sun's L. L. was 72° 29′ 40″ S. Long. D. R. 139° 45′ W. Ship ran from sight to noon 247° (true) 59 miles.

At sight sun bore by compass N 93° E. Variation 11° W.

Required: Position of vessel at sight and noon; error and deviation of compass by altitude azimuth, and true course and distance from noon to Lat. 0°, Long. 180° by Mercator's sailing.

Obs. Alt.	72° 29′ 40″	L. A. T.	12h 0m 0s
Corr. (46)	+ 9′ 33″	Long.	+ 9h 19m 0s
h	72° 39′ 13″ S	G. A. T.	21h 19m 0s
	90° 0′ 0″	Eq. Time	− 1m 46s
Z. D.	17° 20′ 47″ N	G. C. T. 23d	21h 17m 14s
T. D.	12° 41′ 42″ N		
Lat. at Noon	30° 2′ 29″ N	Dec. 23d 20h	12° 40′.7
Diff. Lat.	23′ 6″ N	Corr. for 1.3h	+ 1′.0
Lat. at Sight	30° 25′ 35″ N	Dec. 23d 21.3h	12° 41′.7 N

At Mid. Lat. 30°; Dep. 54.3 =
Diff. Long. 62′ 45″ W

Chron.	16h 36m 23s
Fast	− 24m 52s
	16h 11m 31s
Acc. Rate	+ 4m 2s
G. C. T. 23d	16h 15m 33s
Eq. Time	+ 1m 43s
G. A. T. 23d	16h 17m 16s

Chron. fast Jan. 8	28m 16s
Chron. fast Feb. 26	24m 2s
Lost in 49 days	3m 24s or 204s

49 into 204 = 4s.2 daily rate

Interval from Feb. 26 is 57.7 days
57.7 × 4s.2 = 242s
Acc. Rate losing 4m 2s

Dec. 23d 16h	12° 37′.4
Corr. for .3h	+ .2
Dec. 23d 16.3h	12° 37′.6 N
	−90° 0′.0
P. D.	77° 22′.4

Obs. Alt.	19° 28′ 0″				
Corr. (46)	+ 7′ 14″				
h	19° 35′ 14″			Sec	.02589
Lat.	30° 25′ 35″	Sec	.06435	Sec	.06435
P. D.	77° 22′ 24″	Csc	.01063		
	2)127° 23′ 13″				
s	63° 41′ 36″	Cos	9.64658	Cos	9.64658
s − h	44° 6′ 22″	Sin	9.84260		
s − P. D.	13° 40′ 48″			Cos	9.98751
		Log. Hav.	9.56416		9.72433

L. A. T. 23d	7h 1m 54s
G. A. T. 23d	16h 17m 16s
Long.	9h 15m 22s
Long. at Sight	138° 50′ 30″ W
Diff. Long.	1° 2′ 45″ W
Long. at Noon	139° 53′ 15″ W

Az.	S 93° 27′ E
	180° 0′
True Bearing	N 86° 33′ E
Comp. Bearing	N 93° 0′ E
Error	6° 27′ W
Variation	11° 0′ W
Deviation	4° 33′ E

Lat. A	30° 2′ N	Mer. Parts	1879.0	Long. A	139° 53′ W
Lat. B	0° 0′		0.0	Long. B	180° 0′
Diff. Lat.	30° 2′ or 1802′		1879.0	Diff. Long.	40° 7′ or 2407′

Log. of Diff. Long.	2407 =	13.38148
Log. of Mer. Parts	1879 =	3.27393
Tangent		10.10755 = Course S 52° 1′ W
Sec. of Course 52° 1′	=	.21082
Log. of Diff. Lat.	1802 =	3.25575
Log.		3.46657 = Distance 2928 miles

Answer:

At Sight Lat. 30° 25′ 35″ N. Long. 138° 50′ 30″ W.
At Noon Lat. 30° 2′ 29″ N. Long. 139° 53′ 15″ W.
Error of compass 6° 27′ W. Deviation 4° 33′ E.
True course S 52° 1′ W. Distance 2928 miles.

PROBLEM NO. 3

Sept. 23, 1936. P. M. at ship. Obs. Alt. Sun's L. L. 23° 16′. Dip 29 ft. Chron. read 7h 27m 18s A. M., which was slow on June 18, 8m 29s and on Aug. 1 was slow 5m 32s.

At noon the Obs. Mer. Alt. Sun's L. L. was 52° 47′ 38″ N. Long. D. R. 125° 30′ E. Ship ran from noon to sight 163° (true) 53 miles.

At sight the sun bore by compass S 98° 45′ W. Variation 2° 30′ E.

Required: Position of vessel at sight and noon; error and deviation of compass by altitude azimuth; and true course and distance by Mercator's sailing from noon to Lat. 10° 50′ N. Long. 92° 23′ E.

Obs. M. A.	52° 47′ 38″	L. A. T.	12h 0m 0s
Corr. (46)	+ 10′ 3″	Long.	− 8h 22m 0s
h	52° 57′ 41″ N	G. A. T.	3h 38m 0s
	90° 0′ 0″	Eq. Time	− 7m 31s
Z. D.	37° 2′ 19″ S	G. C. T. 23d	3h 30m 29s
T. D.	1′ 54″ N		
Lat. at Noon	37° 0′ 25″ S	Dec. 23d 2h	0° 3′.4
Diff. Lat.	50′ 42″ S	Corr. for 1.5h	− 1′.5
Lat. at Sight	37° 51′ 7″ S	Dec. 23d 3.5h	0° 1′.9 N

At Mid. Lat. 37°; Dep. 15.5 =
Diff. Long. 19′ 30″ W

Chron.		7h 27m 18s	Chron. slow June 18d		8m 29s
Slow	+	5m 32s	Chron. slow Aug. 1d		5m 32s
		7h 32m 50s	Gained in 44 days		2m 57s or
Acc. Rate	−	3m 33s	44 into 177 = 4s daily rate		
G. C. T. 23d		7h 29m 17s	Interval from Aug. 1,		53.3 days
Eq. Time	+	7m 34s	D. R. 4s × 53.3 = 213s		
			Acc. Rate gaining 3m 33s		
G. A. T. 23d		7h 36m 51s			
			Dec. 23d 6h		0° 0′.5 S
			Corr. for 1.5h	−	1′.5
			Dec. 23d 7.5h		0° 2′.0 S
					−90° 0′.0
			P. D.		89° 58′.0

Obs. Alt.		23° 16′ 0″				
Corr. (46)	+	8′ 35″				
h		23° 24′ 35″			Sec	.03730
Lat.		37° 51′ 7″	Sec	.10259	Sec	.10259
P. D.		89° 58′ 0″	Csc	.00000		
		2)151° 13′ 42″				
s		75° 36′ 51″	Cos	9.39524	Cos	9.39524
s − h		52° 12′ 16″	Sin	9.89774		
s − P. D.		14° 21′ 9″			Cos	9.98623
			Log. Hav.	9.39557		9.52136

L. A. T. 23d	15h 59m 17s	Az.	N	70° 23′ W
G. A. T. 23d	7h 36m 51s			180° 0′
Long. T.	8h 22m 26s	Comp. Bearing	S	109° 37′ W
Long. at Sight	125° 36′ 30″ E	True Bearing	S	98° 45′ W
Diff. Long.	19′ 30″ W			
		Error		10° 52′ E
Long. at Noon	125° 17′ 0″ E	Variation		2° 30′ E
		Deviation		8° 22′ E

Lat. A	37° 0′ S	Mer. Parts	2378.5	Long. A	125° 17′ E
Lat. B	10° 50′ N		649.5	Long B	92° 23′ E
Diff. Lat.	47° 50′ or 2870′		3028.0	Diff. Long.	32° 54′ or 1974′

Log. of Diff. Long. 1974 = 13.29535
Log. of Mer. Parts 3028 = 3.48116

Tangent 9.81419 = Course N 33° 6′ W

Sec. of Course 33° 6′ = .07690
Log. of Diff. Lat. 2870 = 3.45788

Log. 3.53478 = Distance 3426 miles

Answer:

At Sight Lat. 37° 51′ 7″ S.	Long. 125° 36′ 30″ E.
At Noon Lat. 37° 0′ 25″ S.	Long. 125° 17′ 0″ E.
Error of compass 10° 52′ E.	Deviation 8° 22′ E.
True course N 33° 6′ W.	Distance 3426 miles.

PROBLEM NO. 4

Oct. 24, 1936. A. M. at ship. D. R. Lat. 22° 40′ N. Obs. Alt. Sun's L. L. 24° 16′. Dip 26 ft. Chron. read 6h 23m 12s A. M., which was fast on Sept. 25, 8m 12s and Oct. 20 was fast 6m 20s.

Sun bore by compass N 116° E. Variation 19° E.

At noon the Obs. Mer. Alt. Sun's L. L. was 55° 30′ S. Ship ran from sight to noon N 43° W (true) 52 miles.

Required position at sight and noon; error and deviation of compass by altitude azimuth; and true course and distance by Mercator's sailing from noon to Lat. 0° 23′ S. Long. 0° 23′ W.

CORRECTING LONGITUDE

Note.—In practice it is common to work a morning time sight on D. R. latitude. When a noon sight is obtained, the latitude found at noon gives a more correct latitude for the A. M. sight. This correction to the latitude will affect the longitude. Either the entire calculation may be gone through again or the longitude previously found may be corrected by any of the following methods:

(a) Using Table 38 (Bowditch), knowing altitude, latitude, and polar distance, the table gives the error due to 1′ error in latitude.

(b) Using Table 47 (Bowditch), the sun's true bearing having been found for compass correction, and the approximate latitude known, the table gives the longitude factor or error in longitude produced by 1′ error in latitude.

(c) Using Table 2 (Bowditch), using as a course 90° from the bearing find the departure corresponding to the error in the latitude column. The departure in miles is found with the middle latitude as course and the difference in longitude in minutes is found.

The following example will illustrate the above methods:

1st. Work time sight and azimuth with D. R. lat.

Chron.	6h 23m 12s		Chron. fast Sept. 25d	8m 12s	
Fast	− 6m 20s		Chron. fast Oct. 20d	6m 20s	
	6h 16m 52s		Lost in 25 days	1m 52s	or
Acc. Rate	+ 19s			112s	
G. C. T. 24d	6h 17m 11s		25 into 112 = 4s.5 daily rate		
Eq. Time	+ 15m 44s		Interval from Oct. 20, 4.3 days		
			D. R. 4s.5 × 4.3 days = 19s		
G. A. T. 24d	6h 32m 55s		Acc. Rate losing 19s		
			Dec. 24d 6h	11° 42′.2	
			Corr. for .3h	+ .3	
			Dec. 24d 6.3h	11° 42′.5	S
				+90° 0.0′	
			P. D.	101° 42′.5	

Obs. Alt.	24° 16′ 0″				
Corr. (46)	+ 9′ 7″				
h	24° 25′ 7″			Sec	.04070
Lat. D. R.	22° 40′ 0″	Sec	.03491	Sec	.03491
P. D.	101° 42′ 30″	Csc	.00913		
	2)148° 47′ 37″				
s	74° 23′ 48″	Cos	9.42972	Cos	9.42972
s − h	49° 58′ 41″	Sin	9.88411		
s − P. D.	27° 18′ 42″			Cos	9.94866
		Log. Hav.	9.35787		9.45399

L. A. T. 24d	8h 11m 51s	Az.	S 64° 28′ E
G. A. T. 24d	6h 32m 55s		180° 0′
Long. T.	1h 38m 56s	True Bearing	N 115° 32′ E
Long. at Sight	24° 44′ 0″ E	Comp. Bearing	N 116° 0′ E
Diff. Long.	38′ 30″ W		
		Error	0° 28′ W
Long. at Noon	24° 5′ 30″ E	Variation	19° 0′E
		Deviation	19° 28′ W

2d. Find latitude at noon, and the difference between the latitude used and the correct latitude.

	Long. 24° 5′ E		
Obs. Mer. Alt.	55° 30′ 0″	L. A. T.	12h 0m 0s
Corr. (46)	+ 10′ 31″	Long.	− 1h 36m 20s
h	55° 40′ 31″ S	G. A. T.	10h 23m 40s
	90° 0′ 0″	Eq. Time	− 15m 45s
Z. D.	34° 19′ 29″ N	G. C. T. 24d	10h 7m 55s
T. D.	11° 45′ 48″ S		
Lat. at Noon	22° 33′ 41″ N	Dec. 24d 10h	11° 45′.7
Diff. Lat.	38′ 0″ S	Corr. for .1h	+ .1
Lat. at Sight (corr.)	21° 55′ 41″ N	Dec. 24d 10.1h	11° 45′.8 S
Lat. Used	22° 40′ 0″ N		
Lat. Error	44′ 19″	Course N 43° W Dist. 52 miles	
		Diff. Lat. 38′ S Dep. 35.5	
		At Mid. Lat. 22° Dep. 35.5	
		Diff. Long. 38′ 30″ W	

3d. Work time sight with correct latitude, and find the difference between longitude found with D. R. latitude, and that found with correct latitude.

h	24° 25′ 7″		
Corr. Lat.	21° 55′ 41″	Sec	.03261
P. D.	101° 42′ 30″	Csc	.00913
	2)148° 3′ 18″		
s	74° 1′ 39″	Cos	9.43960
s − h	49° 36′ 32″	Sin	9.88175
		Log. Hav.	9.36309
L. A. T. 24d (corr.)	8h 10m 20s		
G. A. T. 24d	6h 32m 55s		
Long. T.	1h 37m 25s		
Long. at Sight (corr.)	24° 21′ 15″ E		
Long. of D. R. Lat.	24° 44′ 0″ E		
Long. Error	22′ 45″ E		

4th. Find the error in longitude approximately by Table 38.

TABLE 38

Lat. error 44′.3; Alt. 24°; Lat. 22°; P. D. 102°
Error in longitude for 1′ of latitude = .5
Lat. error 44′.3 × .5 = Long. error 22′.1 (approximately)

RULE.—In east longitude, body east of meridian, decreased latitude, longitude is decreased.

5th. Find the error in longitude by Table 47.

TABLE 47

True bearing S 64° E (see azimuth in calculation)
Lat. 22°. Lat. error 44′.3
Longitude factor "F" = .51
Lat. error 44′.3 × .51 = 22′.6 longitude error

6th. Find the error in longitude by Table 2.

TABLE 2

Bearing S 64° E. Find course 90° from it, or N 26° E. Opposite lat. 44′.3 find dep. 21′.6. At middle lat. 22° Dep. 21′.6 in lat. column = 23′ error in longitude.

7th. Find course and distance by Mercator's sailing and noon position.

Noon Position

Lat. Noon	22° 33′ 41″ N		Long. at Sight		24° 21′ 15″ E
			Diff. Long.		38′ 30″ W
			Long. at Noon		23° 42′ 45″ E
Lat. A	22° 34′ N	Mer. Parts	1381.5	Long. A	23° 43′ E
Lat. B	0° 23′ S		22.8	Long. B	0° 23′ W
Diff. Lat.	22° 57′ or 1377′		1404.3	Diff. Long.	24° 6′ or 1446′

Log. of Diff. Long. 1446 = 13.16017
Log. of Mer. Parts 1404 = 3.14737

Tangent 10.01280 = Course S 45° 51′ W
Secant of Course 45° 51′ = .15705
Log. of Diff. Lat. 1384 = 3.13893

Log. 3.29598 = Distance 1977 miles

Answer:

At Sight: Lat. 21° 55′ 41″ N. Long. 24° 21′ 15″ E
At Noon: Lat. 22° 33′ 41″ N. Long. 23° 42′ 45″ E
Error of compass 0° 28′ W. Deviation 19° 28′ W
True course S 45° 51′ W. Distance 1977 miles

PROBLEM NO. 5

Feb. 2, 1936. A. M. at ship. D. R. Lat. 36° 59′ S. Obs. Alt. Sun's L. L. 49° 10′. Dip 14 ft. Chron. read 7h 8m 50s A. M., which was slow on Dec. 30, 18m 2s, and on Jan. 6 was slow 19m 10.6s.

Ship ran from sight to noon 225° (true) 32 miles.

Sun bore by compass S 73° E. Variation 5° W.

Obs. Mer. Alt. Sun's L. L. at noon 70° 25′ N.

Required position at sight and noon; error and deviation of compass by altitude azimuth; and true course and distance from noon to Lat. 1° 10′ N. Long. 5° 15′ W by Mercator's sailing?

1st. Time sight and azimuth with D. R. Lat.

Chron.	7h 8m 50s		Chron. slow Dec. 30d		18m 2s	
Slow	+ 19m 11s		Chron. slow Jan. 6d		19m 10.6s	
	7h 28m 1s		Lost in 7 days		1m 8.6s or 68.6s	
Acc. Rate	+ 4m 27s		7 into 68.6 = 9s.8 daily rate			
G. C. T. 2d	7h 32m 28s					
Eq. Time	− 13m 44s		Interval from Jan. 6, 27.3 days			
			D. R. 9s.8 × 27.3 days = 267s			
G. A. T. 2d	7h 18m 44s		Acc. Rate losing 4m 27s			
			Dec. 2d 6h		17° 8′.1	
			Corr. for 1.5 h		− 1′.1	
			Dec. 2d 7.5h		17° 7′.0 S	
					−90° 0′.0	
Obs. Alt.	49° 10′ 0″		P. D.		72° 53′.0	
Corr. (46)	+ 11′ 51″					
h	49° 21′ 51″			Sec	.18626	
Lat.	36° 59′ 0″	Sec	.09756	Sec	.09756	
P. D.	72° 53′ 0″	Csc	.01968			
	2)159° 13′ 51″					
s	79° 36′ 55″	Cos	9.25589	Cos	9.25589	
s − h	30° 15′ 4″	Sin	9.70225			
s − P. D.	6° 43′ 55″			Cos	9.99699	
		Log. Hav.	9.07538		9.53670	
L. A. T. 2d	9h 18m 36s		Az.		N 71° 50′ E	
G. A. T. 2d	7h 18m 44s				180° 0′	
Long. T.	1h 59m 52s		True Bearing		S 108° 10′ E	
Long. at Sight	29° 58′ 0″ E		Comp. Bearing		S 73° 0′ E	
Diff. Long.	28′ 00″ W					
			Error		35° 10′ W	
Long. at Noon	29° 30′ 0″ E		Variation		5° 0′ W	
			Deviation		30° 10′ W	

2d. Find latitude at noon, and the difference between the latitude used and the correct latitude.

Long. at noon 29° 30′ 0″ E

Obs. Mer. Alt.	70° 25′ 0″	L. A. T.	12h 0m 0s
Corr. (46)	+ 12′ 17″	Long.	− 1h 58m 0s
h	70° 37′ 17″ N	G. A. T. 2d	10h 2m 0s
	90° 0′ 0″	Eq. Time	+ 13m 45s
Z. D.	19° 22′ 43″ S	G. C. T. 2d	10h 15m 45s
T. D.	17° 5′ 6″ S		
Lat. at Noon	36° 27′ 49″ S	Dec. 2d 10h	17° 5′.3
Diff. Lat.	22′ 36″ N	Corr. for .3h	− .2
Lat. at Sight (corr.)	36° 5′ 13″ S	Dec. 2d 10.3h	17° 5′.1 S
Lat. Used	36° 59′ 0″ S		
Lat. Error	0° 53′ 47″ or 53′.8	Course S 45° W. Dist. 32 miles = D. Lat. 22.6 N. Dep. 22.6 W At Mid. Lat. 36°. Dep. 22.6 = Diff. Long. 28′ 00″ W	

3d. Work time sight with correct latitude, and find the difference between longitude found with D. R. latitude and that found with correct latitude.

h	49° 21′ 51″		
Corr. Lat.	36° 5′ 13″	Sec	.09252
P. D.	72° 53′ 0″	Csc	.01968
	2)158° 20′ 4″		
s	79° 10′ 2″	Cos	9.27403
s − h	29° 48′ 11″	Sin	9.69637
		Log. Hav.	9.08260
L. A. T. 2d	9h 17m 11s		
G. A. T. 2d	7h 18m 44s		
Long. T.	1h 58m 27s		
Long. at Sight (corr.)	29° 36′ 45″ E		
Long. of D. R. Lat.	29° 58′ 0″ E		
Long. Error	21′ 15″ E		

4th. Find error in longitude by Table 47.

True bearing 72°
Lat. 36°
Factor = .40
.40 × Lat. error 53′.8 = Long. error 21′.5

5th. Find course and distance by Mercator's sailing, and noon position.

Lat. 36° 27′ 49″ S			Long at Sight		29° 36′ 45″ E
Noon Position			Diff. Long.		28′ 00″ W
			Long. at Noon		29° 8′ 45″ E
Lat. A	36° 28′ S	Mer. Parts	2338.8	Long. A	29° 9′ E
Lat. B	1° 10′ N		69.5	Long. B	5° 15′ W
Diff. Lat.	37° 38′ or 2258′		2408.3	Diff. Long.	34° 24′ or 2064′

Log. of Diff. Long. 2064 = 13.31471
Log. of Mer. Parts 2408 = 3.38166

Tangent 9.93305 = Course N 40° 36′ W

Secant of course 40° 36′ = .11960
Log. of Diff. Lat. 2258′ = 3.35372

Log. 3.47332 = Distance 2974 miles

Answer:

At Sight: Lat. 36° 5′ 13″ S. Long. 29° 36′ 45″ E.
At Noon: Lat. 36° 27′ 49″ S. Long. 29° 8′ 45″ E.
Error of compass 35° 10′ W. Deviation 30° 10′ W.
True course N 40° 36′ W. Distance 2974 miles.

PROBLEM NO. 6

Nov. 15, 1936. A. M. at ship. D. R. Lat. 4° 15′ N. Obs. Alt. Sun's L. L. 50° 25′. Dip 30 ft. Chron. read 9h 33m 10s A. M., which was fast on Oct. 22, 3m 28s and losing 4.7s daily.

Sun bore by compass N 122° 30′ E. Variation 5° E.

Ship ran from sight to noon 79° (true) 31 miles.

Obs. Mer. Alt. Sun's L. L. at noon 68° 13′ S.

Required position at sight and noon; error and deviation of compass by altitude azimuth; and true course and distance by Mercator's sailing from noon to Lat. 24° 18′ N. Long. 56° 28′ W.

1st. Time sight and azimuth with D. R. Lat.

Chron.	9h 33m 10s		Interval 24.4 days			
Fast	− 3m 28s		D. R. 4.7s × 24.4 = 115s			
	9h 29m 42s		Acc. Rate losing 1m 55s			
Acc. Rate	+ 1m 55s					
G. C. T. 15d	9h 31m 37s		Dec. 15d 8h		18° 28′.5	
Eq. Time	+ 15m 22s		Corr. for 1.5h		+ .9	
G. A. T. 15d	9h 46m 59s		Dec. 15d 9.5h		18° 29′.4	S
					+ 90° 0′.0	
Obs. Alt.	50° 25′ 0″		P. D.		108° 29′.4	
Corr. (46)	+ 10′ 10″					
h	50° 35′ 10″			Sec	.19729	
Lat. D. R.	4° 15′ 0″	Sec	.00120	Sec	.00120	
P. D.	108° 29′ 24″	Sec	.02302			
	2)163° 19′ 34″					
s	81° 39′ 47″	Cos	9.16137	Cos	9.16137	
s − h	31° 4′ 37″	Sin	9.71281			
s − P. D.	26° 49′ 37″			Cos	9.95055	
		Log. Hav.	8.89840		9.31041	

L. A. T. 15d	9h 49m 17s	Az.	S 53° 45′ E
G. A. T. 15d	9h 46m 59s		180° 0′
Long. T.	2m 18s	True Bearing	N 126° 15′ E
Long. at Sight	0° 34′ 30″ E	Comp. Bearing	N 122° 30′ E
Diff. Long.	30′ 30″ E		
		Error	3° 45′ E
Long. at Noon	1° 5′ 0″ E	Variation	5° 0′ E
		Deviation	1° 15′ W

2d. Find latitude at noon, and the difference between the latitude used and the correct latitude.

Long. at noon 1° 5′ E		L. A. T.	12h 0m 0s
		Long.	− 4m 20s
Obs. Mer. Alt.	68° 13′ 0″	G. A. T.	11h 55m 40s
Corr. (46)	+ 10′ 32″	Eq. Time	− 15m 21s
h	68° 23′ 32″ S	G. C. T. 15d	11h 40m 19s
	90° 0′ 0″		
Z. D.	21° 36′ 28″ N	Dec. 15d 10h	18° 29′.8
T. D.	18° 30′ 48″ S	Corr. for 1.7h	+ 1′.0
Lat. at Noon	3° 5′ 40″ N	Dec. 15d 11.7h	18° 30′.8 S
Diff. Lat.	5′ 54″ S		
Lat. at Sight (corr.)	2° 59′ 46″ N	Course 79° Dist. 31 = Diff. Lat.	
Lat. D. R.	4° 15′ N	5′.9 S Dep. 30.4	
		Mid. Lat. 3° Dep. 30.4 = Diff.	
Lat. Error	1° 15′ 14″ or 75′.2	Long. 30′.5 E	

3d. Work time sight with correct latitude, and find difference of longitude between that found with correct latitude and that found with D. R. latitude.

h	50° 35′ 10″		
Lat.	2° 59′ 46″	Sec	.00060
P. D.	108° 29′ 24″	Csc	.02302
	2)162° 4′ 20″		
s	81° 2′ 10″	Cos	9.19259
s − h	30° 27′ 00″	Sin	9.70482
		Log. Hav.	8.92103
L. A. T. 15d	9h 45m 44s		
G. A. T. 15d	9h 46m 59s		
Long. T.	1m 15s		
Long. at Sight (corr.)	0° 18′ 45″ W		
Long. of D. R. Lat.	0° 34′ 30″ E		
Long. Error	53′15″ E		

4th. Find error in Longitude by Table 47.

True bearing 54°
Lat. 3°
F. = .73
Lat. error 75′.2 × .73 = Long. error 54′.8

5th. Find noon position and course and distance by Mercator's sailing

Lat. at Noon 3° 5′ 40″ N — Long. at Sight 0° 18′ 45″ W
Diff. Long. 30′ 30″ E
Long. at Noon 0° 11′ 45″ E

Lat. A	3° 6′ N	Mer. Parts	184.8	Long. A	0° 12′ E
Lat. B	24° 18′ N		1494.2	Long. B	56° 28′ W
Diff. Lat.	21° 12′ or 1272′		1309.4	D. Long.	56° 40′ or 3400′

Log. of Diff. Long. 3400 = 13.53148
Log. of Mer. Parts 1309 = 3.11694

Tangent 10.41454 = Course N 68° 57′ W

Secant of course 68° 57′ = .44468
Log. of Diff. Lat. 1272 = 3.10449

Log. 3.54917 = Distance 3541 miles

Answer:

At Sight: Lat. 2° 59′ 46″ N. Long. 0° 18′ 45″ W.
At Noon: Lat. 3° 5′ 40″ N. Long. 0° 11′ 45″ E.
Error of compass 3° 45′ E. Deviation 1° 15′ W.
True course N 68° 57′ W. Distance 3541 miles.

CHAPTER XXV

LATITUDE BY MERIDIAN ALTITUDE OF PLANET

This problem is worked the same as latitude by fixed star, with the exception that planet's parallax and semi-diameter must be applied to observed altitude, and the declination is to be corrected for Greenwich Civil Time and date.

RULE:

1. Find the Greenwich Apparent Time (G. A. T.) by applying to the Local Apparent Time (L. A. T.) the longitude in time. West, add. East, subtract.
2. To the G. A. T. apply the Equation of Time. Result will be Greenwich Civil Time (G. C. T.).
3. Take out planet's declination from almanac for Greenwich date, and the difference in small figures between it and next date.
4. On pages 154–157 (N. A.) with the difference at top of page to nearest number, and the G. C. T. on left-hand side to the nearest hour and minute, and read the number obtained from the column by interpolating closely.
5. Apply this number to planet's declination for Greenwich date as follows:
   If declination is increasing, add the correction.
   If declination is decreasing, subtract the correction.
   Result will be true declination.

   For example: Jan. 24th G. C. T. 14h 14m. Required true declination of planet "Venus."

Planet's Dec. Jan. 24d	21° 43′ .0 S	Increasing
Corr. Page 156 (N. A.)	+3 .3	Diff. 56
True Dec. 14h 14m	21° 46′ .3 S	

   Looking in columns 50 and 60, Page 156, 14h 14m on left-hand side, we find by interpolation 33 the correction.

As the declination is increasing, the correction is to be added.

6. The Obs. Mer. Alt. is corrected as follows:
   Parallax (N. A.), add.
   Semi-Diameter (N. A.), add.
   Index error as per sign, if any.
   Dip (Table 14), subtract.
   Refraction (Table 20A), subtract.
   Or the corrections for dip and refraction may be obtained from Table 46 in column for stars.
   Result will be true altitude (h).
7. Find zenith distance, apply declination, and the result will be latitude, as in previous latitude problems.

PROBLEM NO. 1

Oct. 5, 1936. At 9h 13m P. M. (L. A. T.). Long. 19° 30′ W. Obs. Mer. Alt. Planet Saturn 36° 15′ 20″ S. Dip 18 ft. Required Lat.?

L. A. T. 5d	21h 13m 0s	Dec. 5d 0h	7° 5′.0 S
Long.	+ 1h 18m 0s	Corr. 22h 19m	+ 1′.4
G. A. T. 5d	22h 31m 0s	Dec. 5d 22h 19m	7° 6′.4 S
Eq. Time	− 11m 42s		
G. C. T. 5d	22h 19m 18s	Diff. between 5d and 6d 15	
		Enter page 156 columns 10 and 20 and interpolate	
Obs. Mer. Alt.	36° 15′ 20″		
Par. (N. A.)	+ 1″		
	36° 15′ 21″		
S. D. (N. A.)	+ 8″		
	36° 15′ 29″		
Corr. (Table 46)	− 5′ 28″		
h	36° 10′ 1″ S		
	90° 0′ 0″		
Z. D.	53° 49′ 59″ N		
T. D.	7° 6′ 24″ S		
Lat.	**46° 43′ 35″ N**		

PROBLEM NO. 2

Dec. 25, 1936. At 7h 14m P. M. (L. A. T.). Long. 106° 30′ E. Obs. Mer. Alt. Planet Jupiter 41° 12′ N. Dip 28 ft. Required Lat.?

L. A. T. 25d	19h 14m 0s	Dec. 25d 0h	23° 15′.9 Diff. 5
Long.	− 7h 6m 0s	Corr. 12h 8m	− .3 Decreasing
G. A. T. 25d	12h 8m 0s	Dec. 25d 12h 8m	23° 15′.6 S
Eq. Time	+ 11s		
G. C. T.	12h 8m 11s		
Obs. Mer. Alt.	41° 12′ 0″		
Par. (N. A.)	+ 1″		
	41° 12′ 1″		
S. D. (N. A.)	+ 15″		
	41° 12′ 16″		
Corr. (46)	− 6′ 18″		
h	41° 5′ 58″ N		
	90° 0′ 0″		
Z. D.	48° 54′ 2″ S		
T. D.	23° 15′ 36″ S		
Lat.	72° 9′ 38″ S		

PROBLEM NO. 3

Jan. 2, 1936. At 5h 55m A. M. (L. A. T.) Long. 46° 15′ W. Obs. Mer. Alt. Planet Venus 69° 7′ N. Dip 14 ft. Required Lat.?

L. A. T. 2d	5h 55m 0s	Dec. 2d 0h	17° 23′.5 Diff. 167
Long.	+ 3h 5m 0s	Corr. 9h 4m	+ 6′.3 Increasing
G. A. T. 2d	9h 0m 0s	Dec. 2d 9h 4m	17° 29′.8 S
Eq. Time	+ 3m 40s		
G. C. T. 2d	9h 3m 40s		

Obs. Mer. Alt.		69° 7′ 0″
Par.	+	9″
		69° 7′ 9″
S. D.	+	8″
		69° 7′ 17″
Corr. (46)	−	4′ 2″
h		69° 3′ 15″ N
		90° 0′ 0″
Z. D.		20° 56′ 45″ S
T. D.		17° 29′ 48″ S
Lat.		38° 26′ 33″ S

PROBLEM NO. 4

Dec. 8, 1936. At 7h 32m A. M. (L. A. T.) Long. 5° 34′ 30″ W. Obs. Mer. Alt. Planet Mars 84° 28′ S. Dip 40 ft. Required Lat.?

L. A. T. 8d		7h 32m 0s	Dec. 8d 0h		4° 3′.0	Diff. 133
Long.	+	22m 18s	Corr. 7h 46m	+	4′.3	Increasing
G. A. T. 8d		7h 54m 18s	Dec. 8d 7h 46m		4° 7′.3 S	
Eq. Time	−	8m 7s				
G. C. T. 8d		7h 46m 11s				
Obs. Mer. Alt.		84° 28′ 0″				
Par.	+	5″				
		84° 28′ 5″				
S. D.	+	2″				
		84° 28′ 7″				
Corr. (46)	−	6′ 18″				
h		84° 21′ 49″ S				
		90° 0′ 0″				
Z. D.		5° 38′ 11″ N				
T. D.		4° 7′ 18″ S				
Lat.		1° 30′ 53″ N				

PROBLEM NO. 5

Jan. 14, 1936. At 10h 51m A. M. (L. A. T.) Long. 24° 32′ E. Obs. Mer. Alt. Planet Jupiter 73° 32′ 30″ N. Dip 28 ft. Required Lat.?

L. A. T. 14d	10h 51m 0s	Dec. 14d 0h	21° 55′.2	Diff. 14	
Long.	− 1h 38m 8s	Corr. 9h 22m	+ .6	Increasing	
G. A. T. 14d	9h 12m 52s	Dec. 14d 9h 22m	21° 55′.8 S		
Eq. Time	+ 8m 49s				
G. C. T. 14d	9h 21m 41s				
Obs. Mer. Alt.	73° 32′ 30″				
Par.	+ 1″				
	73° 32′ 31″				
S. D.	+ 15″				
	73° 32′ 46″				
Corr. (46)	− 5′ 28″				
h	73° 27′ 18″ N				
	90° 0′ 0″				
Z. D.	16° 32′ 42″ S				
T. D.	21° 55′ 48″ S				
Lat.	38° 28′ 30″ S				

PROBLEM NO. 6

Feb. 12, 1936. At 12h 23m A. M. (L. A. T.) Long. 138° 53′ 30″ W. Obs. Mer. Alt. Planet Venus 48° 47′ 10″ S. Dip 38 ft. Required Lat.?

L. A. T. 12d	0h 23m 0s	Dec. 12d 0h	21° 40′.0	Diff. 66	
Long.	+ 9h 15m 34s	Corr. 9h 53m	− 2′.7	Decreasing	
G. A. T.	9h 38m 34s	Dec. 12d 9h 53m	21° 37′.3 S		
Eq. Time	+ 14m 23s				
G. C. T. 12d	9h 52m 57s				

Obs. Mer. Alt.		48° 47′ 10″
Par. & S. D.	+	14″
		48° 47′ 24″
Corr. (46)	−	6′ 53″
		48° 40′ 31″ S
		90° 0′ 0″
Z. D.		41° 19′ 29″ N
Dec.		21° 37′ 18″ S
Lat.		19° 42′ 11″ N

CHAPTER XXVI

LATITUDE BY EX-MERIDIAN ALTITUDE OF SUN

This problem is to find the latitude of the place, when the sun is not visible at noon.

It is possible at certain seasons of the year to obtain the latitude 28 minutes before or after noon.

When sun's declination is opposite name to latitude of observer the interval is greater; when the latitude and declination are the same name interval is less.

If further away from noon than 28 minutes, the latitude may yet be calculated, but by a different method, called $\phi' \phi''$ method. This method will be explained in another chapter.

RULE:

1. Find the Local Apparent Time (L. A. T.) as follows:
   Correct chronometer and obtain G. C. T.
   Take from N. A. equation of time for G. C. T., and obtain G. A. T.
   Apply to G. A. T. the longitude as follows: East, add. West, subtract.
   Result will be L. A. T.
2. To find the time from noon:
   If L. A. T. is less than 12 hours, subtract it from 12 hours, and the result will be time before noon.
   If L. A. T. is over 12 hours, the time will be past noon.
3. Take out sun's declination from N. A. for Greenwich Civil Time and date.
4. Square the number of minutes from noon.

   NOTE.—To square a number, multiply it by itself. For example: the square of 12 is $12 \times 12 = 144$.

5. Enter Table 26 with lat. and decl. to nearest degree, and read the number obtained from this table in its proper column. Declination will be found from top of page; latitude from side.

   NOTE.—Notice whether lat. and decl. are same or contrary names.

6. Multiply the square of minutes from noon by this number, and the result will be seconds of altitude correction.

7. Reduce the seconds to minutes and seconds, and always add it to sun's observed altitude.

NOTE.—Table 27 is another method of finding the altitude correction. It is based on the same principle as the foregoing rule—that is, the square of the number of minutes from noon multiplied by correction from Table 26 is given directly in this table.

8. After adding to observed altitude the correction, correct altitude for I. E. (if any), and the correction from Table 46 for the sun.

9. Find zenith distance, and apply the declination, as was done in meridian altitude sights.

Result will be latitude at sight.

To find the latitude at noon it will be necessary to allow the difference of latitude made by the ship for the course and distance steered in the interval.

This problem is very useful to the navigator, for if the sun is overcast at noon the latitude by observation would be lost for that day if this example was not used.

PROBLEM NO. 1

March 10, 1936. Ex-Mer. Alt. Sun's L. L. 42° 16′ 28″ S. Dip 18 ft. Chron. read 6h 45m 15s P. M. Long. 94° 16′ W. Lat. D. R. 43° N. Required latitude at sight?

G. C. T. 10d	18h 45m 15s	Dec. 10d 18h	3° 57′.7
Eq. Time	− 10m 20s	Corr. for .8h	− .8
G. A. T.	18h 34m 55s	Dec. 10d 18.8h	3° 56′.9 S
Long.	− 6h 17m 4s		
L. A. T.	12h 17m 51s	17.85×17.85=319	

Time Past Noon	17.85m	From Table 26 = 2″.0 319 × 2″ = 638″
Obs. Alt.	42° 16′ 28″	Alt. Corr. 10′ 38″
Alt. Corr.	+ 10′ 38″	
	42° 27′ 6″	
Corr. (46)	+ 11′ 2″	
h	42° 38′ 8″ S	
	90° 0′ 0″	
Z. D.	47° 21′ 52″ N	
Dec.	3° 56′ 54″ S	
Lat. at Sight	43° 24′ 58″ N	

PROBLEM NO. 2

April 19, 1936. Ex-Mer. Alt. Sun's L. L. 41° 28′ 13″ N. Dip 20 ft. Lat. D. R. 38° S. Long. 105° 15′ E. Chron. read 4h 45m 8s A. M. Required latitude at sight?

G. C. T. 19d	4h 45m 8s	Dec. 19d 4h	11° 5′.7
Eq. Time	+ 48s	Corr. for .8h	+ .7
G. A. T.	4h 45m 56s	Dec. 19d 4.8h	11° 6′.4 N
Long.	+ 7h 1m 0s		
L. A. T.	11h 46m 56s	13.1 × 13.1 = 172	
Time before Noon	13m 4s	From Table 26 = 2″.0 172 × 2″ = 344″	
Obs. Alt.	41° 28′ 13″	Alt. Corr. 5′ 44″	
Alt. Corr.	+ 5′ 44″		
	41° 33′ 57″		
Corr. (46)	+ 10′ 35″		
h	41° 44′ 32″ N		
	90° 0′ 0″		
Z. D.	48° 15′ 28″ S		
Dec.	11° 6′ 24″ N		
Lat. at Sight	37° 9′ 4″ S		

PROBLEM NO. 3

March 11, 1936. Ex-Mer. Alt. Sun's L. L. 45° 38′ 25″ N. Dip 22 ft. Lat. D. R. 48° S. Long. 168° 20′ E. Chron. read 10d 11h 59m 54s P. M., slow 35m 58s. Required latitude at sight?

Chron.	23h 59m 54s	Dec. 11d 0h	3° 51′.8
Slow	+ 35m 58s	Corr. for .6h	− .6
G. C. T. 11d	0h 35m 52s	Dec. 11d 0.6h	3° 51′.2 S
Eq. Time	− 10m 16s		
G. A. T.	0h 25m 36s	21.1×21.1=445	
Long.	+11h 13m 20s	From Table 26=1″.9	
L. A. T.	11h 38m 56s	445×1″.9=845″	
Time before Noon	21m 4s	Alt. Corr. 14′ 5″	
Obs. Alt.	45° 38′ 25″		
Alt. Corr.	+ 14′ 5″		
	45° 52′ 30″		
Corr. (46)	+ 10′ 42″		
h	46° 3′ 12″ N		
	90° 0′ 0″		
Z. D.	43° 56′ 48″ S		
Dec.	3° 51′ 12″ S		
Lat. at Sight	47° 48′ 0″ S		

PROBLEM NO. 4

July 4, 1936. Ex-Mer. Alt. Sun's L. L. 44° 2′ N. Dip 18 ft. Lat. D. R. 23° S. Long. 35° 15′ W. Chron. read 10h 17m 10s A. M., slow 3h 52m 17s. Required latitude at sight?

Chron.	10h 17m 10s	Dec. 4d 14.2h	22° 52′.3 N
Slow	+ 3h 52m 17s		
G. C. T. 4d	14h 9m 27s	15.8×15.8=250	
Eq. Time	− 4m 14s	From Table 26=2″.3	
G. A. T.	14h 5m 13s	250×2″.3=575″	
Long.	− 2h 21m 0s	Alt. Corr. 9′ 35″	
L. A. T.	11h 44m 13s		
Time before Noon	15m 47s		

Obs. Alt.	44° 2′ 0″
Alt. Corr.	+ 9′ 35″
	44° 11′ 35″
Corr. (46)	+ 10′ 44″
h	44° 22′ 19″ N
	90° 0′ 0″
Z. D.	45° 37′ 41″ S
Dec.	22° 52′ 18″ N
Lat. at Sight	22° 45′ 23″ S

PROBLEM NO. 5

Oct. 24, 1936. Ex-Mer. Alt. Sun's L. L. 37° 2′ 15″ S. Dip 18 ft. Lat. D. R. 41° 13′ N. Long. 70° E. Chron. read 7h 7m 41s A. M. slow 16m 19s. Required latitude at sight?

Chron.	7h 7m 41s	Dec. 24d 6h	11° 42′.2
Slow	+ 16m 19s	Corr. for 1.4h	+ 1′.3
G. C. T. 24d	7h 24m 0s	Dec. 24d 7.4h	11° 43′.5 S
Eq. Time.	+ 15m 44s		
		19.7×19.7=388	
G. A. T.	7h 39m 44s	From Table 26 = 1″.8	
Long.	+ 4h 40m 0s	388×1″.8=698″	
		Alt. Corr. 11′ 38″	
L. A. T.	12h 19m 44s		
Time past Noon	19m 44s		
Obs. Alt.	37° 2′ 15″		
Alt. Corr.	+ 11′ 38″		
	37° 13′ 53″		
Corr. (46)	+ 10′ 49″		
h	37° 24′ 42″ S		
	90° 0′ 0″		
Z. D.	52° 35′ 18″ N		
Dec.	11° 43′ 30″ S		
Lat. at Sight	40° 51′ 48″ N		

PROBLEM NO. 6

Sept. 24, 1936. Ex-Mer. Alt. Sun's L. L. 50° 19′ S. Dip 16 ft. Lat. D. R. 38° 50′ N. Long. 6° W. Chron. read 0h 34m 10s P. M., fast 19m 20s. Required latitude at sight?

Chron.	12h 34m 10s	Dec. 24d 12h	0° 29′.8
Fast	− 19m 20s	Corr. for .2h	+ .2
G. C. T. 24d	12h 14m 50s	Dec. 24d 12.2h	0° 30′.0 S
Eq. Time	+ 7m 59s		
G. A. T.	12h 22m 49s	1.2×1.2=1.44	
Long.	− 24m 0s	From Table 26=2″.4	
L. A. T.	11h 58m 49s	1.44×2″.4=3″	
Time before Noon	1m 11s	Alt. Corr. 3″	
Obs. Alt.	50° 19′ 0″		
Alt. Corr.	+ 3″		
	50° 19′ 3″		
Corr. (46)	+ 11′ 22″		
h	50° 30′ 25″ S		
	90° 0′ 0″		
Z. D.	39° 29′ 35″ N		
Dec.	30′ 0″ S		
Lat. at Sight	38° 59′ 35″ N		

PROBLEM NO. 7

Dec. 25, 1936. Ex-Mer. Alt. Sun's L. L. 64° 45′ N. Dip 15 ft. Lat. D. R. 48° 23′ S. Long. 130° E. Chron. read 3h 17m 10s A. M., slow 13m 5s. Required latitude at sight?

Chron.	3h 17m 10s	Dec. 25d 3h 30m	23° 24′.5 S
Slow	+ 13m 5s		
G. C. T. 25d	3h 30m 15s	10.25×10.25=105	
Eq. Time	+ 0s	From Table 26=2″.9	
G. A. T.	3h 30m 15s	105×2″.9=304″	
Long.	+ 8h 40m 0s	Alt. Corr. 5′ 4″	
L. A. T.	12h 10m 15s		
Time past Noon	10m 15s		

Obs. Alt.	64° 45′ 0″
Alt. Corr.	+ 5′ 4″
	64° 50′ 4″
Corr. (46)	+ 12′ 7″
h	65° 2′ 11″ N
	90° 0′ 0″
Z. D.	24° 57′ 49″ S
Dec.	23° 24′ 30″ S
Lat. at Sight	48° 22′ 19″ S

PROBLEM NO. 8

May 29, 1936. Ex-Mer. Alt. Sun's L. L. 64° 25′ S. Dip 10 ft. Lat. D. R. 47° N. Long. 49° 30′ W. Chron. read 11h 17m 56s A. M., slow 3h 53m. Required latitude at sight?

Chron.	11h 17m 56s	Dec. 29d 14h	21° 39′.0
Slow	+ 3h 53m 0s	Corr. for 1.2h	+ .5
G. C. T. 29d	15h 10m 56s	Dec. 29d 15.2h	21° 39′.5 N
Eq. Time	+ 2m 44s		
G. A. T.	15h 13m 40s		
Long.	− 3h 18m 0s		
L. A. T.	11h 55m 40s		
Time before Noon	4m 20s		
Obs. Alt.	64° 25′ 0″	$4.3 \times 4.3 = 18$	
Alt. Corr.	+ 52″	From Table 26 = 2″.9	
	64° 25′ 52″	$18 \times 2''.9 = 52''$	
Corr. (46)	+ 12′ 19″	Alt. Corr. 52″	
h	64° 38′ 11″ S		
	90° 0′ 0″		
Z. D.	25° 21′ 49″ N		
Dec.	21° 39′ 30″ N		
Lat. at Sight	47° 1′ 19″ N		

PROBLEM NO. 9

Jan. 24, 1936. Ex-Mer. Alt. Sun's L. L. 22° 46′ S. Index Error −1′ 25″. Dip 26 ft. Lat. D. R. 48° N. Long. 155° W. Chron. read 10h 5m 2s P. M., slow 7m 15s. Required Latitude at sight?

Chron.		22h 5m 2s	Dec. 24d 22h		19° 19′.0
Slow	+	7m 15s	Corr. for .2h	−	.1
G. C. T. 24d		22h 12m 17s	Dec. 24d 22.2h		19° 18′.9 S
Eq. Time	−	12m 7s			
G. A. T.		22h 0m 10s	19.8×19.8=392		
Long.		−10h 20m 0s	From Table 26=1″.4		
L. A. T.		11h 40m 10s	392×1″.4=549″		
Time before Noon		19m 50s	Alt. Corr. 9′ 9″		
Obs. Alt.		22° 46′ 0″			
Alt. Corr.	+	9′ 9″			
		22° 55′ 9″			
I. E.	−	1′ 25″			
		22° 53′ 44″			
Corr. (46)	+	9′ 8″			
h		23° 2′ 52″ S			
		90° 0′ 0″			
Z. D.		66° 57′ 8″ N			
Dec.		19° 18′ 54″ S			
Lat. at Sight		47° 38′ 14″ N			

PROBLEM NO. 10

July 12, 1936. Ex-Mer. Alt. Sun's L. L. 78° 16′ 30″ S. Dip 26 ft. Lat. D. R. 34° N. Long. 75° 18′ W. Chron. read 5h 0m 28s. P. M Required latitude at sight?

G. C. T. 12d		17h 0m 28s	Dec. 12d 16h		21° 56′.7
Eq. Time	−	5m 28s	Corr. for 1h	−	.3
G. A. T. 12d		16h 55m 0s	Dec. 12d 17h		21° 56′.4 N
Long.	−	5h 1m 12s			
L. A. T.		11h 53m 48s	6.2×6.2=38		
Time before Noon		6m 12s	From Table 26=7″.3		
			38×7″.3=277″		
			Alt. Corr. 4′ 37″		

Obs. Alt.	78° 16′ 30″
Alt. Corr.	+ 4′ 37″
	78° 21′ 7″
Corr. (46)	+ 10′ 36″
h	78° 31′ 43″ S
	90° 0′ 0″
Z. D.	11° 28′ 17″ N
Dec.	21° 56′ 24″ N
Lat. at Sight	33° 24′ 41″ N

PROBLEM NO. 11

Sept. 18, 1936. Ex-Mer. Alt. Sun's L. L. 78° 16′ 30″ S. Dip 26 ft. Lat. D. R. 13° N. Long. 75° 30′ E. Chron. read 7h 3m A. M. Required latitude at sight?

G. C. T. 18d	7h 3m 0s	Dec. 18d 6h	1° 56′.1
Eq. Time	+ 5m 48s	Corr. for 1h	− 1′.0
G. A. T.	7h 8m 48s	Dec. 18d 7h	1° 55′.1 N
Long.	+ 5h 2m 0s		
		$10.8 \times 10.8 = 117$	
L. A. T.	12h 10m 48s	From Table 26 = 10″	
Time after Noon	10m 48s	$117 \times 10'' = 1170''$	
		Alt. Corr. 19′ 30″	
Obs. Alt.	78° 16′ 30″		
Alt. Corr.	+ 19′ 30″		
	78° 36′ 0″		
Corr. (46)	+ 10′ 49″		
h	78° 46′ 49″ S		
	90° 0′ 0″		
Z. D.	11° 13′ 11″ N		
Dec.	1° 55′ 6″ N		
Lat. at Sight	13° 8′ 17″ N		

PROBLEM NO. 12

Feb. 7, 1936. Ex-Mer. Alt. Sun's L. L. 42° 0′ 30″ S. Dip 18 ft. Lat. D. R. 33° N. Long. 94° W. Chron. read 6h 45m 15s P. M. Required latitude at sight?

G. C. T. 7d	18h 45m 15s	Dec. 7d 18h	15° 30′.1
Eq. Time	− 14m 15s	Corr. for .8h	− .6
G. A. T.	18h 31m 0s	Dec. 7d 18.8h	15° 29′.5 S
Long.	− 6h 16m 0s		
L. A. T.	12h 15m 0s	15×15=225	
Time past Noon	15m 0s	From Table 26=2″.1	
		225×2″.1=472″	
		Alt. Corr. 7′ 52″	
Obs. Alt.	42° 0′ 30″		
Alt. Corr.	+ 7′ 52″		
	42° 8′ 22″		
Corr. (46)	+ 11′ 8″		
h	42° 19′ 30″ S		
	90° 0′ 0″		
Z. D.	47° 40′ 30″ N		
Dec.	15° 29′ 30″ S		
Lat. at Sight	32° 11′ 0″ N		

CHAPTER XXVII

LATITUDE BY MERIDIAN ALTITUDE OF MOON

This problem is useful to find the latitude when the moon is on the meridian in daylight, but at night cannot be depended upon on account of the sea horizon not being clear enough for proper altitude.

RULE:

1. Find the Greenwich civil time and date.
2. From N. A. take out moon's declination for nearest hour of G. C. T., and the difference between it and next hour.
3. On page 134 (N. A.) will be found corrections to be applied to declination. Enter this table with difference, or variation per hour, at top of page, and number of minutes past the hour of G. C. T. in left-hand column, and apply the correction to declination as follows.
4. If declination is decreasing, subtract correction; if increasing, add.
   Result will be true declination.
5. From N. A. take out Moon's Horizontal Parallax for the G. C. date.
6. Correct the observed meridian altitude as follows:
   Enter Table 49 (Bowditch) with H. P. at top, and obs. alt. at side, and read the correction.
   After finding this correction by interpolation, enter table for height of eye correction, and apply it to first correction as per sign given.
   The total correction is to be added to obs. alt., with the exception where shown under the black line in the table when using the upper limb.
   The result will be true altitude.
7. Subtract true altitude from 90°, find Z. D., apply declination as in previous meridian altitude observations, and the result will be the latitude.

PROBLEM NO. 1

Feb. 12, 1936. Obs. Mer. Alt. Moon's L. L. 28° 14′ N. Dip 28 ft. Chron. read 3h 18m A. M. Required latitude?

G. C. T. 12d	3h 18m 0s	Dec. 12d 3h	10° 3′.8 Diff. 116
		Corr. for 18m	+ 3′.5
Obs. Mer. Alt.	28° 14′ 0″		
Corr. (49)	+ 55′ 29″	Dec. 12d 3h 18m	10° 7′.3 S
h	29° 9′ 29″ N	H. P. 54′.1	
	90° 0′ 0″		
		Enter Table 49	
Z. D.	60° 50′ 31″ S	Alt. 28° 14′ H. P. 54 = 54′ 45″	
Dec.	10° 7′ 18″ S	Alt. 28° 14′ H. P. 55 = 55′ 54″	
Lat.	70° 57′ 49″ S	Diff.	1′ 9″

$1' 9'' = \frac{69}{60} = 6.9$ change in .1 of Par.

$6.9 \times .1 = 7$ change in .1 of Par.

54′ 45″ + 7″ = 54′ 52″ correction.

Dip 28 ft. = correction +0′ 37″

54′ 52″ + 0′ 37″ = 55′ 29″ total corr.

PROBLEM NO. 2

March 18, 1936. Obs. Mer. Alt. Moon's U. L. (upper limb) 68° 21′ N Dip 26 ft. Chron. read 7h 49m A. M. Required latitude?

G. C. T. 18d	7h 49m 0s	Dec. 18d 7h	20° 48′.5 Diff. 81
		Corr. for 49m	− 6′.6
Obs. Alt.	68° 21′ 0″		
Corr. (49)	+ 25″	Dec. 18d 7h 49m	20° 41′.9 S
h	68° 21′ 25″ N	H. P. 58′.6	
	90° 0′ 0″		
Z. D.	21° 38′ 35″ S	Alt. 68° 21′ H. P. 58′.6 =	−0′ 23″
Dec.	20° 41′ 54″ S	Dip 26 ft. =	+0′ 48″
Lat.	42° 20′ 29″ S	Total Alt. corr.	+0′ 25″

PROBLEM NO. 3

July 12, 1936. Obs. Mer. Alt. Moon's L. L. 24° 18′ 30″ S. Dip 26 ft. Chron. read 6h 14m A. M. Required latitude?

G. C. T. 12d	6h 14m 0s	Dec. 12d 6h	14° 57′.7 Diff. 117
		Corr. for 14m +	2′.7
Obs. Alt.	24° 18′ 30″		
Corr. (49)	+ 1° 3′ 15″	Dec. 12d 6h 14m	15° 0′.4 N
h	25° 21′ 45″ S	H. P. 59′.3	
	90° 0′ 0″		
Z. D.	64° 38′ 15″ N		
Dec.	15° 0′ 24″ N		
Lat.	79° 38′ 39″ N		

PROBLEM NO. 4

May 21, 1936. Obs. Mer. Alt. Moon's U. L. 82° 10′ 13″ S. Dip. 40 ft. Chron. read 12h 33m P. M. Required latitude?

G. C. T. 21d	12h 33m 0s	Dec. 21d 12h	23° 57′.8 Diff. 26
		Corr. for 33m +	1′.4
Obs. Alt.	82° 10′ 13″		
Corr. (49)	− 14′ 26″	Dec. 21d 12h 33m	23° 59′.2 N
h	81° 55′ 47″ S	H. P. 59′.9	
	90° 0′ 0″		
Z. D.	8° 4′ 13″ N		
Dec.	23° 59′ 12″ N		
Lat.	32° 3′ 25″N		

PROBLEM NO. 5

April 18, 1936. Obs. Mer. Alt. Moon's L. L. 46° 58′ 12″ N. Dip 28 ft. Chron. read 9h 7m A. M. Required latitude?

G. C. T. 18d	9h 7m 0s	Dec. 18d 9h	2° 8′.7 Diff. 152
		Corr. for 7m	− 1′.8
Obs. Alt.	46° 58′ 12″		
Corr. (49)	+ 51′ 41″	Dec. 18d 9h 7m	2° 6′.9 S
h	47° 49′ 53″ N	H. P. 60′.4	
	90° 0′ 0″		
Z. D.	42° 10′ 7″ S		
Dec.	2° 6′ 54″ S		
Lat.	44° 17′ 1″ S		

PROBLEM NO. 6

Dec. 6, 1936. Obs. Mer. Alt. Moon's U. L. 82° 28′ 36″ S. Dip 18 ft. Chron. read 6h 14m A. M. Required latitude?

G. C. T. 6d	6h 14m 0s	Dec. 6d 6h	0° 39′.5 Diff. 122
		Corr. for 14m	+ 2′.8
Obs. Alt.	82° 28′ 36″		
Corr. (49)	− 11′ 59″	Dec. 6d 6h 14m	0° 42′.3 S
h	82° 16′ 37″ S	H. P. 55′.0	
	90° 0′ 0″		
Z. D.	7° 43′ 23″ N		
Dec.	0° 42′ 18″ S		
Lat.	7° 1′ 5″ N		

PROBLEM NO. 7

Feb. 12, 1936. Obs. Mer. Alt. Moon's L. L. 49° 36′ S. I. E. −3′ 10″. Dip 38 ft. Chron. read 3h 18m A. M. Required latitude?

G. C. T. 12d	3h 18m 0s	Dec. 12d 3h	10° 3′.8 Diff. 116
		Corr. for 18m	+ 3′.5
Obs. Alt.	49° 36′ 0″		
I. E.	− 3′ 10″	Dec. 12d 3h 18m	10° 7′.3 S
	49° 32′ 50″	H. P. 54′.1	
Corr. (49)	+ 43′ 1″		
h	50° 15′ 51″ S		
	90° 0′ 0″		
Z. D.	39° 44′ 9″ N		
Dec.	10° 7′ 18″ S		
Lat.	29° 36′ 51″ N		

PROBLEM NO. 8

June 24, 1936. Obs. Mer. Alt. Moon's U. L. 37° 12′ 10″ N. I. E. +4′ 20″. Dip 28 ft. Chron. read 4h 26m P. M. Required latitude?

G. C. T. 24d	16h 26m 0s	Dec. 24d 16h	3° 40′.9 Diff. 125
		Corr. for 26m	− 5′.4
Obs. Alt.	37° 12′ 10″		
I. E.	+ 4′ 20″	Dec. 24d 16h 26m	3° 35′.5 N
	37° 16′ 30″	H. P. 55′.1	
Corr. (49)	+ 22′ 26″		
h	37° 38′ 56″ N		
	90° 0′ 0″		
Z. D.	52° 21′ 4″ S		
Dec.	3° 35′ 30″ N		
Lat.	48° 45′ 34″ S		

PROBLEM NO. 9

Dec. 9, 1936. Obs. Mer. Alt. Moon's L. L. 57° 12′ S. Dip 32 ft. Chron. read 8h 20m A. M. Required latitude?

G. C. T. 9d	8h 20m 0s	Dec. 9d 8h	14° 20′.3 Diff. 95
		Corr. for 20m	+ 3′.2
Obs. Alt.	57° 12′ 0″		
Corr. (49)	+ 37′ 59″	Dec. 9d 8h 20m	14° 23′.5 S
h	57° 49′ 59″ S	H. P. 54′.1	
	90° 0′ 0″		
Z. D.	32° 10′ 1″ N		
Dec.	14° 23′ 30″ S		
Lat.	17° 46′ 31″ N		

PROBLEM NO. 10

April 21, 1936. Obs. Mer. Alt. Moon's U. L. 47° 36′ 20″ N. Dip 37 ft. Chron. read 11h 50m A. M. Required latitude?

G. C. T. 21d	11h 50m 0s	Dec. 21d 11h	15° 51′.4 Diff. 122
		Corr. for 50m	+ 10′.1
Obs. Alt.	47° 36′ 20″		
Corr. (49)	+ 17′ 39″	Dec. 21d 11h 50m	16° 1′.5 N
h	47° 53′ 59″ N	H. P. 61′.2	
	90° 0′ 0″		
Z. D.	42° 6′ 1″ S		
Dec.	16° 1′ 30″ N		
Lat.	26° 4′ 31″ S		

PROBLEM NO. 11

March 12, 1936. Obs. Mer. Alt. Moon's L. L. 61° 29′ N. I. E. +3′ 40″. Dip 29 ft. Chron. read 2h 41m A. M. Required latitude?

G. C. T. 12d	2h 41m 0s	Dec. 12d 2h	16° 59′.2 Diff. 93
		Corr. for 41m	+ 6′.4
Obs. Alt.	61° 29′ 0″		
I. E.	+ 3′ 40″	Dec. 12d 2h 41m	17° 5′.6 S
	61° 32′ 40″	H. P. 54′.1	
Corr. (49)	+ 34′ 54″		
h	62° 7′ 34″ N		
	90° 0′ 0″		
Z. D.	27° 52′ 26″ S		
Dec.	17° 5′ 36″ S		
Lat.	44° 58′ 2″ S		

PROBLEM NO. 12

Sept. 8, 1936. Obs. Mer. Alt. Moon's U. L. 74° 12′ S. I. E. −4′ 40″. Dip 40 ft. Chron. read 5h 54m A. M. Required latitude?

G. C. T. 8d	5h 54m 0s	Dec. 8d 5h	23° 58′.4 Diff. 5
		Corr. for 54m	+ .4
Obs. Alt.	74° 12′ 0″		
I. E.	− 4′ 40″	Dec. 8d 5h 54m	23° 58′.8 N
	74° 7′ 20″	H. P. 58′.4	
Corr. (49)	− 5′ 20″		
h	74° 2′ 0″ S		
	90° 0′ 0″		
Z. D.	15° 58′ 00″ N		
Dec.	23° 58′ 48″ N		
Lat.	39° 56′ 48″ N		

CHAPTER XXVIII

MERIDIAN PASSAGE OF MOON

By this method the time of the moon's meridian passage over any meridian may be found.

RULE:

1. From pages 135–136 (N. A.) take out the Greenwich time of transit for the date of the example and the difference between that date and the next.
2. Enter Table 11 (Bowditch) with longitude at side, and transit difference (or daily variation) at top, and apply correction found to Greenwich transit, as follows:
   Longitude West, add.
   Longitude East, subtract.
   Result will be time of moon's meridian passage at ship.

PROBLEM NO. 1

Jan. 28, 1936. Find meridian passage of moon in Long. 84° 24′ W.

Greenwich transit, Jan. 28		15h 50m Diff. 51
Corr. from Table 11	+	12m
Mer. passage, Jan. 28		16h 2m or 4h 2m P. M.

PROBLEM NO. 2

Feb. 11, 1936. Find meridian passage of moon in Long. 128° 14′ E.

Greenwich transit, Feb. 11		2h 37m Diff. 41
Corr. from Table 11	−	14m
Mer. passage, Feb. 11		2h 23m or 2h 23m A. M.

PROBLEM NO. 3

March 10, 1936. Find meridian passage of moon in Long. 178° 23′ W.

Greenwich transit, March 10		1h 16m Diff. 42
Corr. from Table 11	+	21m
Mer. passage, March 10		1h 37m or 1h 37m A. M.

PROBLEM NO. 4

April 18, 1936. Find meridian passage of moon in Long. 8° 16′ E.

Greenwich transit, April 18		9h 7m Diff. 53
Corr. from Table 11	−	1m
Mer. passage, April 18		9h 6m A. M.

PROBLEM NO. 5

June 16, 1936. Find meridian passage of moon in Long. 110° 18′ W.

Greenwich transit, June 16		9h 16m Diff. 60
Corr. (11)	+	18m
Mer. passage, June 16		9h 34m A. M.

Nautical Almanac Method.

1. From Pages 135–136 (N. A.) take out Time of Transit, Meridian of Greenwich for date of problem and Var. per hour in column alongside.
2. Multiply Var. per hour by hours and tenths of Long. in time, and apply to Time of Transit by previous rule.

Example: Problem No. 5.

Long. in time 7h 21m or 7.4h

Greenwich transit, June 16		9h 16m	Var. per hr. 2.4m
Correction	+	18m	7.4h × 2.4m = 17.76 or
			18m correction.
Mer. passage, June 16		9h 34m	

CHAPTER XXIX

LONGITUDE BY FIXED STAR

This problem is to determine the longitude of a place by a fixed star, and is accurate as long as the horizon is clear enough to obtain the proper altitude.

A star in the east and another in the west taken as close to each other as possible, and projected on the chart by Sumner lines, will make an excellent "fix" for the ship.

RULE:

1. Correct chronometer, and find Greenwich civil time and date.
2. From pages 2–3 (N. A.) take out Siderial Time of 0h Civil Time at Greenwich, and correction from table below for G. C. T.
3. Add these three quantities.
   Result will be Greenwich Siderial Time (G. S. T.).
4. From pages 160–161 (N. A.) take out star's right ascension and declination for month.
5. Find polar distance.
6. Correct star's observed altitude as follows:
   Index error as per sign, if any.
   Correction from Table 46 (Bowditch) for dip and refraction, subtract.
   Result will be true altitude (h).
7. Add together true altitude, latitude and polar distance.
   Divide sum by 2 for half sum, and subtract true altitude from half sum for remainder.
8. From Table 44 (Bowditch) take out following logs.:
   Secant of latitude; rejecting 10 from index number.
   Cosecant of polar distance; rejecting 10 from index number.
   Cosine of half sum.
   Sine of remainder.
   Add these four logs. together, and subtract 10 from index number.
9. Log. Haversine (Table 45) that agrees with sum of logs. will be star's hour angle. Always to be read from top of page.

10. Under star's right ascension put down star's hour angle and apply as follows:
    If star bore west, add.
    If star bore east, subtract hour angle from right ascension.
    Result will be Local Siderial Time (L. S. T.).
    NOTE.—If star bore east, and hour angle is greater than right ascension, add 24 hours to right ascension and then subtract.
11. Under L. S. T. put down G. S. T., and subtract less from greater.
    Result will be longitude in time.
12. Turn longitude in time into arc.
    Result will be longitude.
13. Name the longitude as follows:
    Greenwich time best, longitude west.
    Greenwich time least, longitude east.

PROBLEM NO. 1

Jan. 31, 1936. A. M. at ship. Obs. Alt. *Spica 45° 50′ bearing W. Dip 36 ft. Chron. read 1h 14m 35s P. M., which was fast on Jan. 11 31m 34s and gaining 9s daily. Lat. 25° 53′ N. D. R. Long. 94° W. Required longitude?

Chron.	13h 14m 35s	Interval 20.5 days	
Fast	− 31m 34s	D. R. 9s × 20.5 = 184s	
		Acc. Rate 3m 4s gaining	
	12h 43m 1s		
Acc. Rate	− 3m 4s	Dec.	10° 49′.8 S
			+ 90° 0′.0
G. C. T. 31d	12h 39m 57s		
S. T. 0h G. T.	8h 36m 12s	P. D.	100° 49′.8
Corr. 12h 40m	2m 5s		
G. S. T.	21h 18m 14s		
Obs. Alt.	45° 50′ 0″		
Corr. (46)	− 6′ 50″		
h	45° 43′ 10″		
Lat.	25° 53′ 0″	Sec.	.04591
P. D.	100° 49′ 48″	Csc	.00781
	2)172° 25′ 58″		
s	86° 12′ 59″	Cos	8.81947
s − h	40° 29′ 49″	Sin	9.81252
		Log. Hav.	8.68571

Star's R. A.	13h 21m 51s
Star's H. A.	+ 1h 41m 46s
L. S. T.	15h 3m 37s
G. S. T.	21h 18m 14s
Long. T.	6h 14m 37s or Long. 93° 39′ 15″ W

PROBLEM NO. 2

Jan. 30, 1936. A. M. at ship. Obs. Alt. *Vega 43° 57′ bearing E. Dip 36 ft. Chron. read 0h 56m P. M., fast 34m 25s. Lat. 28° 27′ N. Long. D. R. 90° 30′ W. Required longitude?

Chron.	12h 56m 0s	Dec.	38° 43′.2 N
Fast	− 34m 25s		−90° 0′.0
G. C. T. 30d	12h 21m 35s	P. D.	51° 16′.8
S. T. 0h G. T.	8h 32m 15s		
Corr.	2m 2s		
G. S. T.	20h 55m 52s		
Obs. Alt.	43° 57′ 0″		
Corr. (46)	− 6′ 53″		
h	43° 50′ 7″		
Lat.	28° 27′ 0″	Sec	.05590
P. D.	51° 16′ 48″	Csc	.10779
	2)123° 33′ 55″		
s	61° 46′ 57″	Cos	9.67470
s−h	17° 56′ 50″	Sin	9.48875
		Log. Hav.	9.32714

Star's R. A.	18h 34m 45s
Star's H. A.	− 3h 39m 32s
L. S. T.	14h 55m 13s
G. S. T.	20h 55m 52s
Long. T.	6h 0m 39s or Long. 90° 9′ 45″ W

PROBLEM NO. 3

June 12, 1936. P. M. at ship. Obs. Alt. *Regulus 26° 18′ 32″ bearing W. Dip 17 ft. Chron. read 2h 2m 12s P. M., fast 14m 8s. Lat. 37° 18′ N. Long. by D. R. 110° E. Required longitude?

Chron.	14h 2m 12s	Dec.	12° 16′.7 N
Fast	− 14m 8s		−90° 0′.0
G. C. T. 12d	13h 48m 4s	P. D.	77° 43′.3
S. T. 0h G. T.	17h 20m 34s		
Corr.	2m 16s		
G. S. T.	31h 10m 54s		
Obs. Alt.	26° 18′ 32″		
Corr. (46)	− 6′ 0″		
h	26° 12′ 32″		
Lat.	37° 18′ 0″	Sec	.09937
P. D.	77° 43′ 18″	Csc	.01005
	2)141° 13′ 50″		
s	70° 36′ 55″	Cos	9.52102
s−h	44° 24′ 23″	Sin	9.84494
		Log. Hav.	9.47538
Star's R. A.	10h 5m 0s		
Star's H. A.	+ 4h 25m 5s		
L. S. T.	14h 30m 5s		
G. S. T.	7h 10m 54s		
Long.	7h 19m 11s	or 109° 47′ 45″ E	

PROBLEM NO. 4

March 11, 1936. A. M. at ship. Obs. Alt. *Antares 28° 16′ 15′ bearing W. Dip 21 ft. Chron. read 8h 16m 23s P. M., slow 32m 18s. Lat. 22° 18′ S. Long. by D. R. 166° 10′ W. Required longitude?

Chron.	20h 16m 23s	Dec.	26° 17′.6 S
Slow	+ 32m 18s		−90° 0′.0
G. C. T. 11d	20h 48m 41s	P. D.	63° 42′.4
S. T. 0h G. T.	11h 13m 54s		
Corr.	3m 25s		
G. S. T.	32h 6m 0s		

Obs. Alt.	28° 16′ 15″		
Corr. (46)	− 6′ 17″		
h	28° 9′ 58″		
Lat.	22° 18′ 0″	Sec	.03376
P. D.	63° 42′ 24″	Csc	.04743
	2)114° 10′ 22″		
s	57° 5′ 11″	Cos	9.73509
s − h	28° 55′ 13″	Sin	9.68448
		Log. Hav.	9.50076

Star's R. A.	16h 25m 31s		
Star's H. A.	+ 4h 34m 1s		
L. S. T.	20h 59m 32s		
G. S. T.	32h 6m 0s		
Long.	11h 6m 28s	or	166° 37′ W

PROBLEM NO. 5

Dec. 16, 1936. P. M. at ship. Obs. Alt. *Capella 31° 17′ 12″ bearing E. Dip 19 ft. Chron. read 10h 12m 16s P. M., slow 8m 3s. Lat. 6° 48′ N. Long. by D. R. 33° 15′ W. Required longitude?

Chron.	22h 12m 16s	Dec.	45° 56′.2 N
Slow	+ 8m 3s		−90° 0′.0
G. C. T. 16d	22h 20m 19s	P. D.	44° 3′.8
S. T. 0h G. T.	5h 37m 49s		
Corr.	3m 40s		
G. S. T.	28h 1m 48s		
Obs. Alt.	31° 17′ 12″		
Corr. (46)	− 5′ 52″		
h	31° 11′ 20″		
Lat.	6° 48′ 0″	Sec	.00307
P. D.	44° 3′ 48″	Csc	.15774
	2) 82° 3′ 8″		
s	41° 1′ 34″	Cos	9.87761
s − h	9° 50′ 14″	Sin	9.23262
		Log. Hav.	9.27104

Star's R. A.	5h 12m 5s
Star's H. A.	− 3h 24m 46s
L. S. T.	1h 47m 19s
G. S. T.	4h 1m 48s
Long.	2h 14m 29s or 33° 37′ 15″ W

PROBLEM NO. 6

April 16, 1936. P. M. at ship. Obs. Alt. *Aldebaran 23° 13′ 20″ bearing W. Dip 26 ft. Index error −2′. Chron. read 7h 1m 35s P. M., fast 2m 27s. Lat. 11° 47′ S. Long. by D. R. 0°. Required longitude?

Chron.	19h 1m 35s	Dec.	16° 23′.0 N
Fast	− 2m 27s		+90° 0′.0
G. C. T. 16d	18h 59m 8s	P. D.	106° 23′.0
S. T. 0h G. T.	13h 35m 50s		
Corr.	3m 7s		
G. S. T.	32h 38m 5s		
Obs. Alt.	23° 13′ 20″		
I. E.	− 2′ 0″		
	23° 11′ 20″		
Corr. (46)	− 7′ 15″		
h	23° 4′ 5″		
Lat.	11° 47′ 0″	Sec	.00925
P. D.	106° 23′ 0″	Csc	.01800
	2)141° 14′ 5″		
s	70° 37′ 2″	Cos	9.52098
s−h	47° 32′ 57″	Sin	9.86797
		Log. Hav.	9.41620

Star's R. A.	4h 32m 16s
Star's H. A.	+ 4h 5m 39s
L. S. T.	8h 37m 55s
G. S. T.	8h 38m 5s
Long.	10s or 0° 2′ 30″ W

PROBLEM NO. 7

Dec. 1, 1936. P. M. at ship. Obs. Alt. *Capella 31° 17′ 12″ bearing E. Dip 19 ft. Chron. read 9h 18m 16s P. M., slow 8m 3s. Lat. 6° 48′ N. Long. by D. R. 5° W. Required longitude?

Chron.	21h 18m 16s	Dec.	45° 56′.2 N
Slow	+ 8m 3s		−90° 0′.0
G. C. T. 1d	21h 26m 19s	P. D.	44° 3′.8
S. T. 0h G. T.	4h 38m 41s		
Corr.	3m 31s		
G. S. T.	26h 8m 31s		
Obs. Alt.	31° 17′ 12″		
Corr. (46)	− 5′ 52″		
h	31° 11′ 20″		
Lat.	6° 48′ 0″	Sec	.00307
P. D.	44° 3′ 48″	Csc	.15774
	2) 82° 3′ 8″		
s	41° 1′ 34″	Cos	9.87761
s−h	9° 50′ 14″	Sin	9.23262
		Log. Hav.	9.27104
Star's R. A.	5h 12m 5s		
Star's H. A.	− 3h 24m 46s		
L. S. T.	1h 47m 19s		
G. S. T.	2h 8m 31s		
Long.	21m 12s	or 5° 18′ 0″ W	

PROBLEM NO. 8

Feb. 15, 1936. A. M. at ship. Obs. Alt. *Spica 48° 10′ bearing W. Dip 26 ft. Chron. read 1h 14m 35s P. M., which was fast on Jan. 11, 31m 34s and gaining 9s daily. Lat. 25° 53′ N. Long. by D. R. 113° W. Required longitude?

Chron.	13h 14m 35s	Interval 35.5 days	
Fast	− 31m 34s	D. R. 9s × 35.5 = 319s	
	12h 43m 1s	Acc. Rate gaining 5m 19s	
Acc. Rate	− 5m 19s	Dec.	10° 49′.8 S
			+90° 0′.0
G. C. T. 15d	12h 37m 42s		
S. T. 0h G. T.	9h 35m 20s	P. D.	100° 49′.8
Corr.	2m 4s		
G. S. T.	22h 15m 6s		

Obs. Alt.	48° 10′ 0″		
Corr. (46)	− 5′ 52″		
h	48° 4′ 8″		
Lat.	25° 53′ 0″	Sec	.04591
P. D.	100° 49′ 48″	Csc	.00781
	2)174° 46′ 56″		
s	87° 23′ 28″	Cos	8.65818
s − h	39° 19′ 20″	Sin	9.80187
		Log. Hav.	8.51377

Star's R. A.	13h 21m 51s	
Star's H. A.	+ 1h 23m 16s	
L. S. T.	14h 45m 7s	
G. S. T.	22h 15m 6s	
Long.	7h 29m 59s	or 112° 29′ 45″ W

PROBLEM NO. 9

March 20, 1936. P. M. at ship. Obs. Alt. *Betelgeux 32° 17′ 30″ bearing E. Dip 26 ft. Chron. read March 21 1h 16m 23s, which was fast 3m 46s. Lat. 32° 17′ N. Long. by D. R. 165° W. Required longitude?

Chron.	1h 16m 23s	Dec.	7° 23′.8 N
Fast	− 3m 46s		−90° 0′.0
G. C. T. 21d	1h 12m 37s	P. D.	82° 36′.2
S. T. 0h G. T.	11h 53m 19s		
Corr.	12s		
G. S. T.	13h 6m 8s		
Obs. Alt.	32° 17′ 30″		
Corr. (46)	− 6′ 32″		
h	32° 10′ 58″		
Lat.	32° 17′ 0″	Sec	.07293
P. D.	82° 36′ 12″	Csc	.00363
	2)147° 4′ 10″		
s	73° 32′ 5″	Cos	9.45245
s − h	41° 21′ 7″	Sin	9.82000
		Log. Hav.	9.34901

Star's R. A.	5h 51m 44s
Star's H. A.	− 3h 45m 38s
L. S. T.	2h 6m 6s
G. S. T.	13h 6m 8s
Long.	11h 0m 2s or 165° 0′ 30″ W

PROBLEM NO. 10

Feb. 16, 1936. P. M. at ship. Obs. Alt. *Rigel 24° 18′ bearing W. I. E. +2′ 12″. Dip 24 ft. Chron. read 11h 16m 28s P. M., which was fast on Jan. 10, 14m 12s and gaining 2s.8 daily. Lat. 16° 46′ N. Long. by D. R. 7° 45′ E. Required longitude?

Chron.	23h 16m 28s	Interval 38 days	
Fast	− 14m 12s	D. R. 2s.8 × 38 = 106s	
		Acc. Rate gaining 1m 46	
	23h 2m 16s		
Acc. Rate	− 1m 46s	Dec.	8° 16′.5 S
			+90° 0′.0
G. C. T. 16d	23h 0m 30s		
S. T. 0h G. T.	9h 39m 17s	P. D.	98° 16′.5
Corr.	3m 47s		
G. S. T.	32h 43m 34s		
Obs. Alt.	24° 18′ 0″		
I. E.	+ 2′ 12″		
	24° 20′ 12″		
Corr. (46)	− 6′ 56″		
h	24° 13′ 16″		
Lat.	16° 46′ 0″	Sec	.01887
P. D.	98° 16′ 30″	Csc	.00455
	2)139° 15′ 46″		
s	69° 37′ 53″	Cos	9.54165
s − h	45° 24′ 37″	Sin	9.85258
		Log. Hav.	9.41765

Star's R. A.	5h 11m 29s
Star's H. A.	+ 4h 6m 6s
L. S. T.	9h 17m 35s
G. S. T.	8h 43m 34s
Long.	34m 1s or 8° 30′ 15″ E

PROBLEM NO. 11

Feb. 6, 1936. P. M. at ship. Obs. Alt. *Sirius 32° 15′ bearing E. Dip 32 ft. Chron. read 9h 18m 27s P. M., which was slow on Jan. 2, 12m 13s and losing 8s.4 daily. Lat. 28° 32′ N. Long. D. R. 37° 15′ W. Required longitude?

Chron.	21h 18m 27s	Interval 35.9 days	
Slow	+ 12m 13s	D. R. 8s.4 × 35.9 = 301s	
	21h 30m 40s	Acc. Rate losing 5m 1s	
Acc. Rate	+ 5m 1s	Dec.	16° 37′.8 S
			+90° 0′.0
G. C. T. 6d	21h 35m 41s		
S. T. 0h G. T.	8h 59m 51s	P. D.	106° 37′.8
Corr.	3m 33s		
G. S. T.	30h 39m 5s		
Obs. Alt.	32° 15′ 0″		
Corr. (46)	− 7′ 5″		
h	32° 7′ 55″		
Lat.	28° 32′ 0″	Sec	.05624
P. D.	106° 37′ 48″	Csc	.01856
	2)167° 17′ 43″		
s	83° 38′ 51″	Cos	9.04396
s − h	51° 30′ 56″	Sin	9.89363
		Log. Hav.	9.01239

Star's R. A.	6h 42m 22s	
Star's H. A.	− 2h 29m 41s	
L. S. T.	4h 12m 41s	
G. S. T.	6h 39m 5s	
Long.	2h 26m 24s	or 36° 36′ 0″ W

PROBLEM NO. 12

Oct. 28, 1936. A. M. at ship. Obs. Alt. *Procyon 28° 49′ 40″ bearing W. I. E. +3′ 10″. Dip 33 ft. Chron. read 9h 12m 28s A. M., which was fast on Aug. 9, 8m 49s and losing 4s.4 daily. Lat. 14° 23′ S. Required longitude?

Chron.	9h 12m 28s	Interval 80.4 days	
Fast	− 8m 49s	D. R. 4s.4×80.4 = 354s	
		Acc. Rate losing 5m 54s	
	9h 3m 39s		
Acc. Rate	+ 5m 54s	Dec.	5° 23′.3 N
			+90° 0′.0
G. C. T. 28d	9h 9m 33s		
S. T. 0h G. T.	2h 24m 38s	P. D.	95° 23′.3
Corr.	1m 30s		
G. S. T.	11h 35m 41s		
Obs. Alt.	28° 49′ 40″		
I. E.	+ 3′ 10″		
	28° 52′ 50″		
Corr. (46)	− 7′ 23″		
h	28° 45′ 27″		
Lat.	14° 23′ 0″	Sec	.01383
P. D.	95° 23′ 18″	Csc	.00192
	2)138° 31′ 45″		
s	69° 15′ 52″	Cos	9.54907
s − h	40° 30′ 25″	Sin	9.81260
		Log. Hav.	9.37742

Star's R. A.	7h 36m 0s	
Star's H. A.	+ 3h 53m 51s	
L. S. T.	11h 29m 51s	
G. S. T.	11h 35m 41s	
Long.	5m 50s	or 1° 27′ 30″ W

CHAPTER XXX

LONGITUDE BY PLANET

This problem is worked in the same manner as longitude by fixed star, with the exception that the planet's declination and right ascension must be corrected for Greenwich civil time.

RULE:

1. Find G. C. T. and date.
2. Find G. S. T. as in previous example.
3. From N. A. take out planet's declination for Greenwich date 0 hours, and difference between it and next date.
   From pages 154–157 (N. A.) take out correction for declination, with difference (or daily variation) at top of page, and G. C. T. at left. Apply this correction for true declination.
4. Find polar distance.
5. From N. A. take out planet's right ascension for Greenwich date 0 hours, and difference between it and next date.
   From Pages 154–157 (N. A.) take out correction for right ascension, with difference (or daily variation) at top of page, and G. C. T. at left. Apply this correction for true right ascension.
6. Correct observed altitude as follows:
   Index error as per sign, if any.
   Parallax and Semi-Diameter from (N. A.), add.
   Dip and refraction from Table 46, subtract.
   Result will be true altitude (h).
7. Add together true altitude, latitude and polar distance. Divide sum by two for half sum, and subtract true altitude from half sum for remainder.
8. From Table 44 take out following logs:
   Secant of latitude; rejecting 10 from index number.
   Cosecant of polar distance; rejecting 10 from index number.

Cosine of half sum.
Sine of remainder.
Add these four logs. together.

9. Log. Haversine (45) that agrees with sum of logs., will be planet's hour angle (H. A.), always read from top of page.
10. Under true right ascension put down hour angle, and apply as follows:
If star bore west, add.
If star bore east, subtract hour angle from right ascension.
Result will be L. S. T.
11. Find the difference between L. S. T. and G. S. T. and the result will be the longitude.

PROBLEM NO. 1

Jan. 31, 1936. A. M. at ship. Obs. Alt. Planet Mars 18° 55′ bearing E. Dip 36 ft. Chron. read 11h 11m 13s A. M., which was fast 34m 34s. Lat. 25° 53′ N. Long. by D. R. 9° W. Required longitude?

Chron.	11h 11m 13s	Dec. 31d 0h	7° 31′.5
Fast	− 34m 34s	Corr. for 10h 37m	− 8′.2
G. C. T. 31d	10h 36m 39s	Dec. 31d 10h 37m	7° 23′.3 S
S. T. 0h G. T.	8h 36m 12s		+90° 0′.0
Corr.	1m 44s	P. D.	97° 23′.3
G. S. T.	19h 14m 35s		
Obs. Alt.	18° 55′ 0″		
H. P. & S. D.	+ 6″		
	18° 55′ 6″		
Corr. (46)	− 8′ 42″		
h	18° 46′ 24″		
Lat.	25° 53′ 0″	Sec	.04591
P. D.	97° 23′ 18″	Csc	.00362
	2)142° 2′ 42″		
s	71° 1′ 21″	Cos	9.51214
s − h	52° 14′ 57″	Sin	9.89800
		Log. Hav.	9.45967

R. A. Jan. 31d 0h	22h 58m 0s	
Corr. for 10h 37m	+ 1m 17s	
R. A. 31d 10h 37m	22h 59m 17s	
*H. A.	− 4h 19m 45s	
L. S. T.	18h 39m 32s	
G. S. T.	19h 14m 35s	
Long.	35m 3s	or 8° 45′ 45″ W

PROBLEM NO. 2

May 6, 1936. A. M. at ship. Obs. Alt. Planet Saturn 30° 16′ 28″ bearing E. Dip 16 ft. Chron. read 4h 16m 28s A. M., fast 3m 28s. Lat. 27° 18′ N. Long. by D. R. 13° 0′ E. Required longitude?

Chron.	4h 16m 28s	Dec. 6 0h	5° 44′.1
Fast	− 3m 28s	Corr. for 4h 13m	− .4
G. C. T. 6d	4h 13m 0s	Dec. 6d 4h 13m	5° 43′.7 S
S. T. 0h G. T.	14h 54m 41s		+90° 0′.0
Corr.	42s		
		P. D.	95° 43′.7
G. S. T.	19h 8m 23s		
Obs. Alt.	30° 16′ 28″		
H. P. & S. D.	+ 8″		
	30° 16′ 36″		
Corr. (46)	− 5′ 35″		
h	30° 11′ 1″		
Lat.	27° 18′ 0″	Sec	.05129
P. D.	95° 43′ 42″	Csc	.00218
	2)153° 12′ 43″		
s	76° 36′ 21″	Cos	9.36484
s − h	46° 25′ 20″	Sin	9.86000
		Log. Hav.	9.27831

R. A. 6d 0h	23h 25m 31s	
Corr. for 4h 13m	+ 4s	
R. A. 6d 4h 13m	23h 25m 35s	
*H. A.	− 3h 26m 37s	
L. S. T.	19h 58m 58s	
G. S. T.	19h 8m 23s	
Long.	50m 35s	or 12° 38′ 45″ E

PROBLEM NO. 3

July 11, 1936. P. M. at ship. Obs. Alt. Planet Venus 28° 39′ 10″ bearing W. I. E. +3′ 20″. Dip 28 ft. Chron. read 4h 28m 30s P. M.. which was fast on March 12, 4m 16s and losing 4s.7 daily. Lat. 37° 19′ N. Long. by D. R. 7° 30′ E. Required longitude?

Chron.	16h 28m 30s	Interval 121.7 days	
Fast	− 4m 16s	D. R. 4s.7 × 121.7 = 572s	
	16h 24m 14s	Acc. Rate losing 9m 32s	
Acc. Rate	+ 9m 32s	Dec. 11d 0h	22° 35′.7
		Corr. for 16h 34m	− 7′.1
G. C. T. 11d	16h 33m 46s		
S. T. 0h G. T.	19h 14m 54s	Dec. 11d 16h 34m	22° 28′.6 N
Corr.	2m 43s		−90° 0′.0
G. S. T.	35h 51m 23s	P. D.	67° 31′.4
Obs. Alt.	28° 39′ 10″		
I. E.	+ 3′ 20″		
	28° 42′ 30″		
H. P. & S. D.	+ 10″		
	28° 42′ 40″		
Corr. (46)	− 6′ 57″		
h	28° 35′ 43″		
Lat.	37° 19′ 0″	Sec	.09947
P. D.	67° 31′ 24″	Csc	.03431
	2)133° 26′ 7″		
s	66° 43′ 3″	Cos	9.59689
s − h	38° 7′ 20″	Sin	9.79052
		Log. Hav.	9.52119

R. A. 11d 0h	7h 34m 25s
Corr. for 16h 34m +	3m 39s
R. A. 11d 16h 34m	7h 38m 4s
*H. A.	+ 4h 41m 29s
L. S. T.	12h 19m 33s
G. S. T.	11h 51m 23s
Long.	28m 10s or 7° 2′ 30″ E

PROBLEM NO. 4

Feb. 11, 1936. P. M. at ship. Obs. Alt. Planet Mars 19° 37′ 40″ bearing W. I. E. −2′ 10″. Dip 31 ft. Chron. read 9h 17m 48s A. M., which was fast on Nov. 12, 1935, 7m 18s and losing 9s.3 daily. Lat. 14° 39′ N. Long. by D. R. 140° E. Required longitude?

Chron.		9h 17m 48s	Interval 91.4 days	
Fast	−	7m 18s	D. R. 9s.3 × 91.4 = 850s	
		9h 10m 30s	Acc. Rate losing 14m 10s	
Acc. Rate	+	14m 10s	Dec. 11d 0h	4° 5′.0
			Corr. for 9h 24m	− 7′.4
G. C. T. 11d		9h 24m 40s		
S. T. 0h G. T.		9h 19m 34s	Dec. 11d 9h 24m	3° 57′.6 S
Corr.		1m 33s		+90° 0′.0
G. S. T.		18h 45m 47s	P. D.	93° 57′.6

Obs. Alt.		19° 37′ 40″		
I. E.	−	2′ 10″		
		19° 35′ 30″		
H. P. & S. D.	+	6″		
		19° 35′ 36″		
Corr. (46)	−	8′ 10″		
h		19° 27′ 26″		
Lat.		14° 39′ 0″	Sec	.01435
P. D.		93° 57′ 36″	Csc	.00104
		2)128° 4′ 2″		
s		64° 2′ 1″	Cos	9.64132
s − h		44° 34′ 35″	Sin	9.84626
			Log. Hav.	9.50297

R. A. 11d 0h		23h 29m 28s
Corr. for 9h 24m	+	1m 7s
R. A. 11d 9h 24m		23h 30m 35s
*H. A.	+	4h 34m 49s
L. S. T.		28h 5m 24s
G. S. T.		18h 45m 47s
Long.		9h 19m 37s or 139° 54′ 15″ E

PROBLEM NO. 5

Sept. 8, 1936. A. M. at ship. Obs. Alt. Planet Saturn 21° 17′ 35″ bearing W. Dip 40 ft. Chron. read 8h 42m 37s A. M., which was slow on June 9, 17m 18s and losing 7s.3 daily. Lat. 41° 17′ N. Long. by D. R. 79° W. Required longitude?

Chron.		8h 42m 37s	Interval 91.4 days	
Slow	+	17m 18s	D. R. 7s.3 × 91.4 = 667s	
		8h 59m 55s	Acc. Rate losing 11m 7s	
Acc. Rate	+	11m 7s	Dec. 8d 0h	6° 17′.9
			Corr. for 9h 11m	+ .8
G. C. T. 8d		9h 11m 2s		
S. T. 0h G. T.		23h 7m 30s	Dec. 8d 9h 11m	6° 18′.7 S
Corr.		1m 31s		+90° 0′.0
G. S. T.		32h 20m 3s	P. D.	96° 18′.7
Obs. Alt.		21° 17′ 35″		
H. P. & S. D.	+	9″		
		21° 17′ 44″		
Corr. (46)	−	8′ 41″		
h		21° 9′ 3″		
Lat.		41° 17′ 0″	Sec	.12410
P. D.		96° 18′ 42″	Csc	.00264
		2)158° 44′ 45″		
s		79° 22′ 22″	Cos	9.26580
s − h		58° 13′ 19″	Sin	9.92946
			Log. Hav.	9.32200

R. A. 8d 0h		23h 24m 47s
Corr. for 9h 11m	−	6s
R. A. 8d 9h 11m		23h 24m 41s
*H. A.	+	3h 38m 8s
L. S. T.		27h 2m 49s
G. S. T.		32h 20m 3s
Long.		5h 17m 14s or 79° 18′ 30″ W

PROBLEM NO. 6

Aug. 16, 1936. A. M. at ship. Obs. Alt. Planet Venus 24° 38′ 50″ bearing E. I. E. +4′ 30″. Dip 29 ft. Chron. read 5h 28m 32s A. M., which was slow on May 9, 14m 39s and gaining 3s.7 daily. Lat. 36° 56′ S. Long. by D. R. 62° 15′ E. Required longitude?

Chron.	5h 28m 32s	Interval 99.2 days	
Slow	+ 14m 39s	D. R. 3s.7 × 99.2 = 367s	
	5h 43m 11s	Acc. Rate gaining 6m 7s	
Acc. Rate	− 6m 7s	Dec. 16d 0h	10° 38′.4
G. C. T. 16d	5h 37m 4s	Corr. for 5h 37m	− 6′.5
S. T. 0h G. T.	21h 36m 50s	Dec. 16d 5h 37m	10° 31′.9 N
Corr.	55s		+90° 0′.0
G. S. T.	27h 14m 49s	P. D.	100° 31′.9

Obs. Alt.	24° 38′ 50″		
I. E.	+ 4′ 30″		
	24° 43′ 20″		
H. P. & S. D.	+ 10″		
	24° 43′ 30″		
Corr. (46)	− 7′ 23″		
h	24° 36′ 7″		
Lat.	36° 56′ 0″	Sec	.09727
P. D.	100° 31′ 54″	Csc	.00738
	2)162° 4′ 1″		
s	81° 2′ 0″	Cos	9.19273
s − h	56° 25′ 53″	Sin	9.92076
		Log. Hav.	9.21814

R. A. 16d 0h	10h 33m 30s		
Corr. for 5h 37m	+ 1m 5s		
R. A. 16d 5h 37m	10h 34m 35s		
*H. A.	− 3h 11m 53s		
L. S. T.	7h 22m 42s		
G. S. T.	3h 14m 49s		
Long.	4h 7m 53s	or	61° 58′ 15″ E

CHAPTER XXXI

LONGITUDE BY MOON

This problem is worked in the same manner as longitude by planet, with the exception of correcting the moon's altitude.

The observation is to be preferred in the day time, when the altitude can be observed more correctly, and in many cases the "upper limb" will be the most accurate for observation.

RULE:

1. Find G. S. T. as before.
2. From N. A. take out Moon's declination and right ascension for Greenwich date and the nearest hour to G. C. T., and the difference between them and next hour.
3. Enter Page 134 (N. A.) with difference at top of page, and time past hour on left-hand side, and read the correction to be applied to Declination and Right Ascension.
4. Find polar distance.
5. Correct observed altitude as follows:
   Index error as per sign, if any.
   Correction to altitude (Table 49), to be added for all "lower limb" observations, and for all "upper limb" observations until the altitude exceeds 67° to 68° (or under the black line in "upper limb" observations).
   Apply to this correction the correction for Height of Eye found in small table below.
   Apply total correction to observed altitude, and the result will be true altitude (h).
6. Add together true altitude, latitude and polar distance. Divide sum by 2 for half sum, and subtract true altitude from half sum for remainder.
7. From Table 44 take out the following logs.:
   Secant of latitude; rejecting 10 from index number.
   Cosecant of polar distance; rejecting 10 from index number.

Cosine of half sum.
Sine of remainder.
Add these four logs. together.

8. Log. Haversine (45) that agrees with sum of logs. will be Moon's Hour Angle (H. A.) always read from top of page.
9. Under true right ascension put down hour angle, and apply as follows:
   If moon bore west, add.
   If moon bore east, subtract.
   Result will be Local Siderial Time (L. S. T.).
10. Find the difference between L. S. T. and G. S. T. and the result will be the longitude.

PROBLEM NO. 1

May 17, 1936. P. M. at ship. Obs. Alt. Moon's L. L. 21° 41′ 18″ bearing W. I. E. +3′ 40″. Dip 15 ft. Chron. read 10h 43m 18s P. M., which was slow on April 12, 3m 29s and losing 4s.2 daily. Lat. 32° 46′ N. Long. by D. R. 134° W. Required longitude?

Chron.	22h 43m 18s	Interval 35.9 days	
Slow	+ 3m 29s	D. R. 4s.2×35.9 = 151s	
	22h 46m 47s	Acc. Rate 2m 31s losing	
Acc. Rate	+ 2m 31s	Dec. 17d 22h	10° 54′.2
		Corr. for 49m	+ 11′.2
G. C. T. 17d	22h 49m 18s		
S. T. 0h G. T.	15h 38m 3s	Dec. 17d 22h 49m	11° 5′.4 N
Corr.	3m 45s		−90° 0′.0
G. S. T.	38h 31m 6s	P. D.	78° 54′.6
Obs. Alt.	21° 41′ 18″	H. P. 60′.4	
I. E.	+ 3′ 40″		
	21° 44′ 58″		
Corr. (49)	+ 1° 6′ 27″		
h	22° 51′ 25″		
Lat.	32° 46′ 0″	Sec	.07527
P. D.	78° 54′ 36″	Csc	.00818
	2)134° 32′ 1″		
s	67° 16′ 0″	Cos	9.58709
s−h	44° 24′ 35″	Sin	9.84497
		Log. Hav.	9.51551 = H. A.

R. A. 17d 22h		0h 50m 25s
Corr. for 49m	+	1m 54s
R. A. 17d 22h 49m		0h 52m 19s
Moon's H. A.	+	4h 39m 23s
L. S. T.		5h 31m 42s
G. S. T.		14h 31m 6s
Long.		8h 59m 24s or 134° 51′ 0″ W

PROBLEM NO. 2

Dec. 10, 1936. A. M. at ship. Obs. Alt. Moon's U. L. 31° 8′ 30″ bearing E. I. E. −2′ 15″. Dip 21 ft. Chron. read Dec. 9, 9h 12m 37s P. M., which was fast on Sept. 12, 7m 49s and losing 3s.8 daily. Lat. 23° 39′ S. Long. by D. R. 111° E. Required longitude?

Chron.		21h 12m 37s	Interval 88.9 days	
Fast	−	7m 49s	D. R. 3s.8 × 88.9 = 338s	
		21h 4m 48s	Acc. Rate 5m 38s losing	
Acc. Rate	+	5m 38s	Dec. 9d 21h	16° 18′.8
G. C. T. 9d		21h 10m 26s	Corr. for 10m	+ 1′.5
S. T. 0h G. T.		5h 10m 13s	Dec. 9d 21h 10m	16° 20′.3 S
Corr.		3m 29s		−90° 0′.0
G. S. T.		26h 24m 8s	P. D.	73° 39′.7
Obs. Alt.		31° 8′ 30″	H. P. 54′.0	
I. E.	−	2′ 15″		
		31° 6′ 15″		
Corr. (49)	+	25′ 27″		
h		31° 31′ 42″		
Lat.		23° 39′ 0″	Sec	.03810
P. D.		73° 39′ 42″	Csc	.01790
		2)128° 50′ 24″		
s		64° 25′ 12″	Cos	9.63526
s − h		32° 53′ 30″	Sin	9.73484
			Log. Hav.	9.42610 = H. A.

Moon's R. A. 9d 21h	13h 56m 10s	
Corr. for 10m	+ 19s	
Moon's R. A. 9d 21h 10m	13h 56m 29s	
Moon's H. A.	− 4h 8m 46s	
L. S. T.	9h 47m 43s	
G. S. T.	2h 24m 8s	
Long.	7h 23m 35s	or 110° 53′ 45″ E

PROBLEM NO. 3

Jan. 7, 1936. A. M. at ship. Obs. Alt. Moon's L. L. 34° 39′ 10″ bearing W. I. E. +2′ 10″. Dip 58 ft. Chron. read 0h 49m 23s A. M., which was slow on Nov. 6, 42m 12s and gaining 10s.8 daily. Lat. 39° 17′ N. Long. by D. R. 22° E. Required longitude?

Chron.	0h 49m 23s	Interval 62.1 days	
Slow	+ 42m 12s	D. R. 10s.8 × 62.1 = 671s	
	1h 31m 35s	Acc. Rate 11m 11s gaining	
Acc. Rate	− 11m 11s	Dec. 7d 1h	24° 58′.9
		Corr. for 20m	− .6
G. C. T. 7d	1h 20m 24s		
S. T. 0h G. T.	7h 1m 34s	Dec. 7d 1h 20m	24° 58′.3 N
Corr.	13s		−90° 0′.0
G. S. T.	8h 22m 11s	P. D.	65° 1′.7
Obs. Alt.	34° 39′ 10″	H. P. 57′.4	
I. E.	+ 2′ 10″		
	34° 41′ 20″		
Corr. (49)	+ 54′ 1″		
h	35° 35′ 21″		
Lat.	39° 17′ 0″	Sec	.11125
P. D.	65° 1′ 42″	Csc	.04263
	2)139° 54′ 3″		
s	69° 57′ 1″	Cos	9.53509
s − h	34° 21′ 40″	Sin	9.75159
		Log. Hav.	9.44056 = H. A.

Moon's R. A. 7d 1h		5h 36m 51s
Corr. for 20m	+	49s
Moon's R. A. 7d 1h 20m		5h 37m 40s
Moon's H. A.	+	4h 13m 25s
L. S. T.		9h 51m 5s
G. S. T.		8h 22m 11s
Long.		1h 28m 54s or 22° 13′ 30″ E

PROBLEM NO. 4

Aug. 15, 1936. A. M. at ship. Obs. Alt. Moon's U. L. 28° 10′ 40″ bearing E. I. E. −3′ 40″. Dip 14 ft. Chron. read 1h 16m 32s P. M., which was slow on May 10, 12m 39s and gaining 4s.4 daily. Lat. 21° 48′ N. Long. by D. R. 104° W. Required longitude?

Chron.	13h 16m 32s	Interval 97.5 days
Slow	+ 12m 39s	D. R. 4s.4 × 97.5 = 429s
	13h 29m 11s	Acc. Rate 7m 9s gaining
Acc. Rate	− 7m 9s	Dec. 15d 13h 16° 47′.0
		Corr. for 22m − 3′.7
G. C. T. 15d	13h 22m 2s	
S. T. 0h G. T.	21h 32m 53s	Dec. 15d 13h 22m 16° 43′.3 N
Corr.	2m 12s	−90° 0′.0
G. S. T.	34h 57m 7s	P. D. 73° 16′.7
Obs. Alt.	28° 10′ 40″	H. P. 56′.5
I. E.	− 3′ 40″	
	28° 7′ 0″	
Corr. (49)	+ 28′ 58″	
h	28° 35′ 58″	
Lat.	21° 48′ 0″	Sec .03222
P. D.	73° 16′ 42″	Csc .01876
	2)123° 40′ 40″	
s	61° 50′ 20″	Cos 9.67390
s − h	33° 14′ 22″	Sin 9.73889
		Log. Hav. 9.46377 = H. A.

Moon's R. A. 15d 13h		8h 21m 5s
Corr. for 22m	+	48s
Moon's R. A. 15d 13h 22m		8h 21m 53s
Moon's H. A.	−	4h 21m 7s
L. S. T.		4h 0m 46s
G. S. T.		10h 57m 7s
Long.		6h 56m 21s or 104° 5′ 15″ W

PROBLEM NO. 5

July 26, 1936. P. M. at ship. Obs. Alt. Moon's L. L. 23° 18′ 50″ bearing W. Dip 13 ft. Chron. read 10h 12m 39s A. M., which was fast on May 13, 5m 19s and losing 6s.6 daily. Lat. 43° 10′ N. Long. by D. R. 140° 0′ E. Required longitude?

Chron.	10h 12m 39s	Interval 74.4 days	
Fast	− 5m 19s	D. R. 6s.6 × 74.4 = 491s	
	10h 7m 20s	Acc. Rate 8m 11s losing	
Acc. Rate	+ 8m 11s	Dec. 26d 10h	16° 28′.0
		Corr. for 16m	+ 2′.4
G. C. T. 26d	10h 15m 31s		
S. T. 0h G. T.	20h 14m 2s	Dec. 26d 10h 16m	16° 30′.4 S
Corr.	1m 41s		+90° 0′.0
G. S. T.	30h 31m 14s	P. D.	106° 30′.4
Obs. Alt.	23° 18′ 50″	H. P. 54′.3	
Corr. (49)	+ 58′ 58″		
h	24° 17′ 48″		
Lat.	43° 10′ 0″	Sec	.13705
P. D.	106° 30′ 24″	Csc	.01827
	2)173° 58′ 12″		
s	86° 59′ 6″	Cos	8.72096
s − h	62° 41′ 18″	Sin	9.94867
		Log. Hav.	8.82495 = H. A.

Moon's R. A. 26d 10h		13h 52m 50s
Corr. for 16m	+	31s
Moon's R. A. 26d 10h 16m		13h 53m 21s
Moon's H. A.	+	1h 59m 51s
L. S. T.		15h 53m 12s
G. S. T.		6h 31m 14s
Long.		9h 21m 58s or 140° 29′ 30″ E

PROBLEM NO. 6

Nov. 23, 1936. P. M. at ship. Obs. Alt. Moon's U. L. 28° 14′ 50″ bearing E. I. E. +3′ 50″. Dip 57 ft. Chron. read Nov. 23, 3h 18m 32s, which was slow on Aug. 16, 19m 48s and gaining 3s.2 daily. Lat. 41° 18′ S. Long. by D. R. 177° E. Required longitude?

Chron.	3h 18m 32s		Interval 99.2 days	
Slow	+ 19m 48s		D. R. 3s.2 × 99.2 = 317s	
	3h 38m 20s		Acc. rate 5m 17s gaining	
Acc. Rate	− 5m 17s		Dec. 23d 3h	1° 25′.2
			Corr. for 33m	− 7′.7
G. C. T. 23d	3h 33m 3s			
S. T. 0h G. T.	4h 7m 9s		Dec. 23d 3h 33m	1° 17′.5 S
Corr.	35s			−90° 0′.0
G. S. T.	7h 40m 47s		P. D.	88° 42′.5
Obs. Alt.	28° 14′ 50″		H. P. 58′.8	
I. E.	+ 3′ 50″			
	28° 18′ 40″			
Corr. (49)	+ 26′ 33″			
h	28° 45′ 13″			
Lat.	41° 18′ 0″	Sec	.12421	
P. D.	88° 42′ 30″	Csc	.00011	
	2)158° 45′ 43″			
s	79° 22′ 51″	Cos	9.26547	
s − h	50° 37′ 38″	Sin	9.88820	
		Log. Hav.	9.27799 = H. A.	

Moon's R. A. 23d 3h	22h 54m 7s		
Corr. for 33m	+ 1m 11s		
Moon's R. A. 23d 3h 33m	22h 55m 18s		
Moon's H. A.	− 3h 26m 32s		
L. S. T.	19h 28m 46s		
G. S. T.	7h 40m 47s		
Long.	11h 47m 59s	or	176° 59′ 45″ E

CHAPTER XXXII

LATITUDE BY EX-MERIDIAN ALTITUDE OF FIXED STAR

The method of ex-meridian altitudes for obtaining latitude by heavenly bodies other than the sun is to be preferred to meridian altitudes, for the reason that the latitude is found immediately at time of observation without waiting for the body to arrive at the meridian. The observation must be taken, however, within a reasonable period before or after body's meridian passage—i.e., 26 minutes.

RULE:

1. Find the G. C. T. and date.
2. Find the G. S. T. by adding together the G. C. T., Siderial Time for 0h Greenwich Time (page 2, N. A.), and correction from table below for G.C.T.
3. Find the L. S. T. by applying to G. S. T. the longitude in time as follows:
   East longitude, add.
   West longitude, subtract.
4. Take out star's declination and right ascension from page 160 (N. A.).
5. Subtract the Right Ascension from L. S. T. Result will be Star's Hour Angle (H. A.).

   NOTE.—If R. A. is greater than L. S. T., add 24 hours to L. S. T.

6. If H. A. is less than 24 hours, subtract it from 24 hours.
   Result will be time before Meridian Passage (M. P.).
   If H. A. is greater than 24 hours, result will be time past M. P.
7. Square the number of minutes and tenths from M.P.
8. Multiply the square of minutes by the Variation of Altitude in 1 minute from M. P., obtained from Table 26.
   This product will give the altitude correction in seconds, and is always to be added to observed altitude.

9. Correct altitude for index error, if any, and correction from Table 46, and obtain true altitude (h).
10. Subtract "h" from 90°, find Z. D., and apply declination as in other latitude problems. Result will be latitude at observation.

PROBLEM NO. 1

May 20, 1936. P. M. at ship. Ex-Mer. Alt. *Arcturus 53° 53′ 45′ bearing S. Dip 19 ft. Chron. read 6h 2m 30s P. M., which was fast 2m 30s. Lat. by D. R. 55° 20′ N. Long. 70° 4′ E. Required latitude at sight?

Chron.	18h 2m 30s	Star's Dec. 19° 30′.7 N
Fast	− 2m 30s	
		Time from M. P. 20.3×20.3 = 412
G. C. T. 20d	18h 0m 0s	From Table 26 Var. Alt. in 1m = 1″.9
S. T. 0h G. T.	15h 49m 53s	
Corr.	2m 57s	412×1″.9 = 783″
		Alt. Corr. +13′ 3″
G. S. T.	33h 52m 50s	
Long. T.	+ 4h 40m 16s	
L. S. T.	38h 33m 6s	
*R. A.	−14h 12m 48s	
*H. A.	24h 20m 18s	
Time from M. P.	20m 18s	
Obs. Alt.	53° 53′ 45″	
Alt. Corr.	+ 13′ 3″	
	54° 6′ 48″	
Corr. (46)	− 4′ 58″	
h	54° 1′ 50″ S	
	90° 0′ 0″	
Z. D.	35° 58′ 10″ N	
Dec.	19° 30′ 42″ N	
Lat. at Sight	55° 28′ 52″ N	

PROBLEM NO. 2

Feb. 9, 1936. A. M. at ship. Ex-Mer. Alt. *Regulus 67° 49′ 20″ bearing N. I. E. +2′ 40″. Dip 38 ft. Chron. read 9h 14m 25s A. M., which was slow 4m 38s. Lat. by D. R. 9° S. Long. 132° 47′ W. Required latitude at sight?

Chron.	9h 14m 25s	Dec. 12° 16′.6 N
Slow	+ 4m 38s	
		Time from M. P. 23.9×23.9=571
G. C. T. 9d	9h 19m 3s	Table 26 Var. Alt. in 1m=5″.3
S. T. 0h G. T.	9h 11m 41s	571×5″.3=3026″
Corr.	1m 32s	Alt. Corr. +50′ 26″
G. S. T.	18h 32m 16s	
Long.	− 8h 51m 8s	
L. S. T.	9h 41m 8s	
*R. A.	10h 5m 1s	
*H. A.	23h 36m 7s	
Time from M. P.	23m 53s	
Obs. Alt.	67° 49′ 20″	
I. E.	+ 2′ 40″	
	67° 52′ 0″	
Alt. Corr.	+ 50′ 26″	
	68° 42′ 26″	
Corr. (46)	− 6′ 24″	
h	68° 36′ 2″ N	
	90° 0′ 0″	
Z. D.	21° 23′ 58″ S	
Dec.	12° 16′ 36″ N	
Lat. at Sight	9° 7′ 22″ S	

PROBLEM NO. 3

Jan. 12, 1936. A. M. at ship. Ex-Mer. Alt. *Spica 52° 38′ 49″ bearing S. I. E. −4′ 10″. Dip 33 ft. Chron. read 2h 13m 12s P. M., which was fast 7m 58s. Lat. by D. R. 26° N. Long. 117° 33′ W. Required latitude at sight?

Chron.	14h 13m 12s	Dec. 10° 49′.7 S
Fast	− 7m 58s	
		Time from M. P. 16.8×16.8=282
G. C. T. 12d	14h 5m 14s	Table 26 Var. Alt. in 1m=2″.9
S. T. 0h G. T.	7h 21m 17s	282×2″.9=818″
Corr.	2m 19s	Alt. Corr. +13′ 38″
G. S. T.	21h 28m 50s	
Long.	− 7h 50m 12s	
L. S. T.	13h 38m 38s	
*R. A.	13h 21m 50s	
*H. A.	16m 48s	
Time from M. P.	16m 48s	
Obs. Alt.	52° 38′ 49″	
I. E.	− 4′ 10″	
	52° 34′ 39″	
Alt. Corr.	+ 13′ 38″	
	52° 48′ 17″	
Corr. (46)	− 6′ 22″	
h	52° 41′ 55″ S	
	90° 0′ 0″	
Z. D.	37° 18′ 5″ N	
Dec.	10° 49′ 42″ S	
Lat. at Sight	26° 28′ 23″ N	

PROBLEM NO. 4

Sept. 16, 1936. P. M. at ship. Ex-Mer. Alt. *Nunki 69° 43′ 40″ bearing N. I. E. +5′ 40″. Dip 34 ft. Chron. read 10h 13m 29s A. M., which was slow 32m 14s. Lat. by D. R. 46° S. Long. 121° 13′ E. Required latitude at sight?

Chron.	10h 13m 29s	Dec. 26° 22′.6 S
Slow	+ 32m 14s	
		Time from M. P. 20×20=400
G. C. T. 16d	10h 45m 43s	Table 26 Var. Alt. in 1m=3″.6
S. T. 0h G. T.	23h 39m 3s	400×3″.6=1440″
Corr.	1m 46s	Alt. Corr. +24′ 0″
G. S. T.	10h 26m 32s	
Long.	+ 8h 4m 52s	
L. S. T.	18h 31m 24s	
*R. A.	18h 51m 22s	
Time from M. P.	19m 58s	
Obs. Alt.	69° 43′ 40″	
I. E.	+ 5′ 40″	
	69° 49′ 20″	
Alt. Corr.	+ 24′ 0″	
	70° 13′ 20″	
Corr. (46)	− 6′ 4″	
h	70° 7′ 16″ N	
	90° 0′ 0″	
Z. D.	19° 52′ 44″ S	
Dec.	26° 22′ 36″ S	
Lat. at Sight	46° 15′ 20″ S	

PROBLEM NO. 5

Oct. 13, 1936. A. M. at ship. Ex-Mer. Alt. *Betelgeux 39° 24′ 50″ bearing S. I. E. −4′ 30″. Dip 32 ft. Chron. read 11h 32m 14s A. M., which was fast 18m 23s. Lat. by D. R. 58° N. Long. 107° 44′ W. Required latitude at sight?

Chron.	11h 32m 14s	Dec. 7° 23′.9 N
Fast	− 18m 23s	
		Time from M. P. 21.5×21.5 = 462
G. C. T. 13d	11h 13m 51s	Table 26 Var. Alt. in 1m = 1″.3
S. T. 0h G. T.	1h 25m 30s	462×1″.3 = 601″
Corr.	1m 51s	Alt. Corr. +10′ 1″
G. S. T.	12h 41m 12s	
Long.	− 7h 10m 56s	
L. S. T.	5h 30m 16s	
*R. A.	5h 51m 46s	
Time from M. P.	21m 30s	
Obs. Alt.	39° 24′ 50″	
I. E.	− 4′ 30″	
	39° 20′ 20″	
Alt. Corr.	+ 10′ 1″	
	39° 30′ 21″	
Corr. (46)	− 6′ 44″	
h	39° 23′ 37″ S	
	90° 0′ 0″	
Z. D.	**50° 36′ 23″ N**	
Dec.	7° 23′ 54″ N	
Lat. at Sight	**58° 0′ 17″ N**	

PROBLEM NO. 6

June 24, 1936. P. M. at ship. Ex-Mer. Alt. *Antares 73° 49′ 28″ bearing S. Dip 40 ft. Chron. read 6h 8m 12s P. M., which was fast 8m 28s. Lat. by D. R. 11° S. Long. 69° 13′ E. Required latitude at sight?

Chron.	18h 8m 12s	Dec. 26° 17′.7 S
Fast	− 8m 28s	
		Time from M. P. 21.9×21.9=480
G. C. T. 24d	17h 59m 44s	Table 26 Var. Alt. in 1m=6″.7
S. T. 0h G. T.	18h 7m 52s	480×6″.7=3216″
Corr.	2m 57s	Alt. Corr. +53′ 36″
G. S. T.	12h 10m 33s	
Long	+ 4h 36m 52s	
L. S. T.	16h 47m 25s	
*R. A.	16h 25m 33s	
Time from M. P.	21m 52s	
Obs. Alt.	73° 49′ 28″	
Alt. Corr.	+ 53′ 36″	
	74° 43′ 4″	
Corr. (46)	− 6′ 29″	
h	74° 36′ 35″ S	
	90° 0′ 0″	
Z. D.	15° 23′ 25″ N	
Dec.	26° 17′ 42″ S	
Lat. at Sight	10° 54′ 17″ S	

CHAPTER XXXIII

LATITUDE BY EX-MERIDIAN ALTITUDE OF PLANET

This problem is practically the same as ex-meridian of fixed stars, with the exception that is necessary to correct the planet's declination and right ascension for G. C. T.

RULE:

1. Find the G. C. T. and date.
2. Find the G. S. T. as in previous example.
3. Find the L. S. T. as in previous example.
4. Take out planet's declination from N. A. for G.C.T. 0h, and correct same for G. C. T.
5. Take out planet's right ascension from N. A. for G. C. T. 0h, and correct same for G. C. T.
6. Subtract right ascension from L. S. T., and result will be planet's hour angle (H. A.).
   If right ascension is greater than L. S. T., add 24 hours to L. S. T.
7. If H. A. is less than 24 hours, subtract it from 24 hours.
   Result will be time before meridian passage (M. P.).
   If H. A. is greater than 24 hours, result will be time past M. P.
8. Square the number of minutes and tenths from M.P.
9. Multiply the square of minutes from M. P., by the Variation of Altitude in 1 minute from M. P., obtained from Table 26.
   This product will give the altitude correction in seconds, and is always to be added to observed altitude.
10. Correct altitude for index error, if any; parallax and semi-diameter (N. A.), add; and correction from Table 26, subtract, and obtain true altitude (h).
11. Subtract "h" from 90°, find Z. D., and apply declination as in other latitude problems. Result will be latitude at observation.

PROBLEM NO. 1

Oct. 16, 1936. P. M. at ship. Ex-Mer. Alt. Planet Venus 68° 23′ 40″ bearing N. I. E. +5′ 30″. Dip 39 ft. Chron. read 5h 39m 12s A. M. which was slow 36m 41s. Lat. by D. R. 40° S. Long. 107° 33′ E. Required latitude at sight?

Chron.		5h 39m 12s	Dec. 16d 0h	18° 31′.5
Slow	+	36m 41s	Corr. for 6h 16m	+ 5′.8
G. C. T. 16d		6h 15m 53s	Dec. 16d 6h 16m	18° 37′.3 S
S. T. 0h G. T.		1h 37m 19s		
Corr.		1m 2s	R. A. 16d 0h	15h 14m 23s
			Corr. for 6h 16m	+ 1m 18s
G. S. T.		7h 54m 14s		
Long.	+	7h 10m 12s	R. A. 16d 6h 16m	15h 15m 41s
L. S. T.		15h 4m 26s	Time from M. P.	11.2×11.2=125
*R. A.		15h 15m 41s	Table 26 Var. Alt. in 1m=4″.0	
			125×4″.0=500″	
*H. A.		23h 48m 45s	Alt. Corr.	+8′ 20″
Time from M. P.		11m 15s		
Obs. Alt.		68° 23′ 40″		
I. E.	+	5′ 30″		
		68° 29′ 10″		
Alt. Corr.	+	8′ 20″		
		68° 37′ 30″		
H. P. & S. D.	+	11″		
		68° 37′ 41″		
Corr. (46)	−	6′ 30″		
h		68° 31′ 11″ N		
		90° 0′ 0″		
Z. D.		21° 28′ 49″ S		
Dec.		18° 37′ 18″ S		
Lat. at Sight		40° 6′ 07″ S		

PROBLEM NO. 2

Nov. 27, 1936. A. M. at ship. Ex-Mer. Alt. Planet Mars 49° 38′ 15″ bearing S. I. E. −3′ 40″. Dip 32 ft. Chron. read 6h 22m 16s P. M., which was fast 8m 13s. Lat. by D. R. 38° N. Long. 145° 53′ W. Required latitude at sight?

Chron.	18h 22m 16s	Dec. 27d 0h	1° 33′.5
Fast	− 8m 13s	Corr. for 18h 14m	+ 10′.5
G. C. T. 27d	18h 14m 3s	Dec. 27d 18h 14m	1° 44′.0 S
S. T. 0h G. T.	4h 22m 55s		
Corr.	3m 0s	*R. A. 27d 0h	12h 29m 19s
		Corr. for 18h 14m	+ 1m 39s
G. S. T.	22h 39m 58s		
Long.	− 9h 43m 32s	R. A. 27d 18h 14m	12h 30m 58s
L. S. T.	12h 56m 26s	Time from M. P.	25.5×25.5=650
*R. A.	12h 30m 58s	Table 26 Var. Alt. in 1m=2″.4	
		650×2″.4=1560″	
Time from M. P.	25m 28s	Alt. Corr.	+26′ 0″

Obs. Alt.	49° 38′ 15″	
I. E.	− 3′ 40″	
	49° 34′ 35″	
Alt. Corr.	+ 26′ 0″	
	50° 0′ 35″	
H. P. & S. D.	+ 6″	
	50° 0′ 41″	
Corr. (46)	− 6′ 22″	
h	49° 54′ 19″	S
	90° 0′ 0″	
Z. D.	40° 5′ 41″	N
Dec.	1° 44′ 0″	S
Lat. at Sight	38° 21′ 41″	N

PROBLEM NO. 3

July 4, 1936. P. M. at ship. Ex-Mer. Alt. Planet Jupiter 61° 18′ 40″ bearing N. I. E. +2′ 40″. Dip 28 ft. Chron. read 11h 48m 13s A. M., which was fast 3m 48s. Lat. by D. R. 51° S. Long. 160° 0′ E. Required latitude at sight?

Chron.	11h 48m 13s	Dec. 4d 0h	22° 17′.4
Fast	− 3m 48s	Corr. for 11h 44m	− .3
G. C. T. 4d	11h 44m 25s	Dec. 4d 11h 44m	22° 17′.1 S
S. T. 0h G. T.	18h 47m 18s		
Corr.	1m 56s	R. A. 4d 0h	17h 2m 41s
		Corr. for 11h 44m	− 13s
G. S. T.	6h 33m 39s		
Long.	+10h 40m 0s	R. A. 4d 11h 44m	17h 2m 28s
L. S. T.	17h 13m 39s	Time from M. P.	11.2×11.2=125
*R. A.	17h 2m 28s	Table 26 Var. Alt. in	1m=2′.4
			125×2′.4=300″
Time from M. P.	11m 11s	Alt. Corr.	+5′ 0″

Obs. Alt.	61° 18′ 40″	
I. E.	+ 2′ 40″	
	61° 21′ 20″	
Alt. Corr.	+ 5′ 0″	
	61° 26′ 20″	
H. P. & S. D.	+ 23″	
	61° 26′ 43″	
Corr. (46)	− 5′ 43″	
h	61° 21′ 0″	N
	90° 0′ 0″	
Z. D.	28° 39′ 0″	S
Dec.	22° 17′ 6″	S
Lat. at Sight	50° 56′ 6″	S

PROBLEM NO. 4

Dec. 26, 1936. P. M. at ship. Ex-Mer. Alt. Planet Saturn 69° 38′ 50″ bearing S. I. E. −3′ 10″. Dip 31 ft. Chron. read 5h 49m 30s P. M., which was fast 11m 14s. Lat. by D. R. 13° N. Long. 12° 33′ W. Required latitude at sight?

Chron.	17h 49m 30s	Dec. 26d 0h	7° 4′.8
Fast	− 11m 14s	Corr. for 17h 38m	− 1′.3
G. C. T. 26d	17h 38m 16s	Dec. 26d 17h 38m	7° 3′.5 S
S. T. 0h G. T.	6h 17m 15s		
Corr.	2m 54s	R. A. 26d 0h	23h 15m 16s
		Corr. for 17h 38m	+ 11s
G. S. T.	23h 58m 25s		
Long.	− 50m 12s	R. A. 26d 17h 38m	23h 15m 27s
L. S. T.	23h 8m 13s	Time from M. P.	7.2×7.2=52
*R. A.	23h 15m 27s	Table 26 Var. Alt. in	1m=5″.6
			52×5″.6=291″
Time from M. P.	7m 14s	Alt. Corr.	+4′ 51″

Obs. Alt.	69° 38′ 50″	
I. E.	− 3′ 10″	
	69° 35′ 40″	
Alt. Corr.	+ 4′ 51″	
	69° 40′ 31″	
Par. & S. D.	+ 9″	
	69° 40′ 40″	
Corr. (46)	− 5′ 48″	
h	69° 34′ 52″	S
	90° 0′ 0″	
Z. D.	20° 25′ 8″	N
Dec.	7° 3′ 30″	S
Lat. at Sight	13° 21′ 38″	N

PROBLEM NO. 5

Aug. 28, 1936. P. M. at ship. Ex-Mer. Alt. Planet Venus 47° 48′30″ bearing S. I. E. −3′ 40″. Dip 37 ft. Chron. read 5h 47m 38s A. M., which was slow 48m 16s. Lat. by D. R. 47° N. Long. 99° 23′ E. Required latitude at sight?

Chron.	5h 47m 38s	Dec. 28d 0h	4° 50′.6
Slow	+ 48m 16s	Corr. for 6h 36m	− 8′.3
G. C. T. 28d	6h 35m 54s	Dec. 28d 6h 36m	4° 42′.3 N
S. T. 0h G. T.	22h 24m 8s		
Corr.	1m 5s	R. A. 28d 0h	11h 28m 29s
		Corr. for 6h 36m	+ 1m 14s
G. S. T.	5h 1m 7s		
Long.	+ 6h 37m 32s	R. A. 28d 6h 36m	11h 29m 43s
L. S. T.	11h 38m 39s	Time from M. P. 8.9×8.9=79	
*R. A.	11h 29m 43s	Table 26 Var. Alt. in 1m=2″.0	
		79×2″.0=158″	
Time from M. P.	8m 56s	Alt. Corr. +2′ 38″	

Obs. Alt.	47° 48′ 30″
I. E.	− 3′ 40″
	47° 44′ 50″
Alt. Corr.	+ 2′ 38″
	47° 47′ 28″
H. P. & S. D.	+ 11″
	47° 47′ 39″
Corr. (46)	− 6′ 51″
h	47° 40′ 48″ S
	90° 0′ 0″
Z. D.	42° 19′ 12″ N
Dec.	4° 42′ 18″ N
Lat. at Sight	47° 1′ 30″ N

PROBLEM NO. 6

Oct. 18, 1936. A. M. at ship. Ex-Mer. Alt. Planet Mars 73° 49′ 10″ bearing S. I. E. +4′ 30″. Dip 34 ft. Chron. read 1h 17m 23s P. M., which was slow 12m 18s. Lat. by D. R. 23° N. Long. 66° 0′ W. Required latitude at sight?

Chron.	13h 17m 23s		
Slow	+ 12m 18s		
G. C. T. 18d	13h 29m 41s		
S. T. 0h G. T.	1h 45m 13s		
Corr.	2m 13s		
G. S. T.	15h 17m 7s		
Long.	− 4h 24m 0s		
L. S. T.	10h 53m 7s		
*R. A.	11h 1m 37s		
Time from M. P.	8m 30s		
Obs. Alt.	73° 49′ 10″		
I. E.	+ 4′ 30″		
	73° 53′ 40″		
Alt. Corr.	+ 8′ 17″		
	74° 1′ 57″		
H. P. & S. D.	+ 5″		
	74° 2′ 2″		
Corr. (46)	− 5′ 59″		
h	73° 56′ 3″	S	
	90° 0′ 0″		
Z. D.	16° 3′ 57″	N	
Dec.	7° 42′ 12″	N	
Lat. at Sight	23° 46′ 9″	N	

Dec. 18d 0h	7° 50′.0	
Corr. for 13h 30m	− 7′.8	
Dec. 18d 13h 30m	7° 42′.2	N
R. A. 18d 0h	11h 0m 20s	
Corr. for 13h 30m	+ 1m 17s	
R. A. 18d 13h 30m	11h 1m 37s	

Time from M. P. 8.5 × 8.5 = 72
Table 26 Var. Alt. in 1m = 6″.9
72 × 6″.9 = 497″
Alt. Corr. +8′ 17″

CHAPTER XXXIV

LATITUDE BY EX-MERIDIAN ALTITUDE OF MOON

RULE:

1. Find the G. C. T. and date.
2. Find the G. S. T.
3. Find the L. S. T.
4. Take out moon's declination and right ascension for Greenwich date, and to the nearest hour of G. C. T.
5. Take out corrections from Page 134 (N. A.) for declination and right ascension, as in previous moon observations.
6. Subtract R. A. from L. S. T. and find moon's hour angle (H. A.).
   If R. A. is greater than L. S. T., add 24 hours to L. S. T.
7. If H. A. is greater than 24 hours, result will be time past M. P.
   If H. A. is less than 24 hours, subtract it from 24 hours.
   Result will be time before meridian passage (M. P.).
8. Square the number of minutes and tenths from M. P.
9. Multiply the square of minutes from M. P., by the Variation of Altitude in 1 minute from M. P., obtained from Table 26.
   This product will give the altitude correction in seconds, and is always to be added to observed altitude.
10. Correct altitude for index error, if any; and correction from Table 49, and obtain true altitude (h).
11. Subtract "h" from 90°, find Z. D., and apply declination as in other latitude problems.
    Result will be latitude at observation.

PROBLEM NO. 1

Oct. 12, 1936. A. M. at ship. Ex-Mer. Alt. Moon's U. L. 67° 38′ 10″ bearing S. I. E. −2′ 50″. Dip 35 ft. Chron. read 5h 12m 37s P. M., which was slow 14m 36s. Lat. by D. R. 22° N. Long. 113° W. Required latitude at sight?

Chron.	17h 12m 37s	Dec. 12d 17h	0° 21′.2
Slow	+ 14m 36s	Corr. for 27m	+ 5′.4
G. C. T. 12d	17h 27m 13s	Dec. 12d 17h 27m	0° 26′.6 S
S. T. 0h G. T.	1h 21m 33s		
Corr.	2m 52s	R. A. 12d 17h	11h 12m 51s
		Corr. for 27m	+ 50s
G. S. T.	18h 51m 38s		
Long.	− 7h 32m 0s	R. A. 12d 17h 27m	11h 13m 41s
L. S. T.	11h 19m 38s	H. P. 54′.5	
Moon's R. A.	11h 13m 41s		
		Time from M. P. 6×6 = 36	
Time from M. P.	5m 57s	Table 26 Var. Alt. in 1m = 4″.9	
		36×4″.9 = 176″	
Obs. Alt.	67° 38′ 10″	Alt. Corr. +2′ 56″	
I. E.	− 2m 50s		
	67° 35′ 20″		
Alt. Corr.	+ 2′ 56″		
	67° 38′ 16″		
Corr. (49)	− 25″		
h	67° 37′ 51″ S		
	90° 0′ 0″		
Z. D.	22° 22′ 9″ N		
Dec.	0° 26′ 36″ S		
Lat. at Sight	21° 55′ 33″ N		

PROBLEM NO. 2

July 4, 1936. P. M. at ship. Ex-Mer. Alt. Moon's L. L. 37° 28′ 14″ bearing S. I. E. +3′ 10″. Dip 39 ft. Chron. read 11h 18m 38s A. M., which was slow 15m 16s. Lat. by D. R. 29° N. Long. 180°. Required latitude at sight?

Chron.	11h 18m 38s	Dec. 4d 11h	22° 39′.1
Slow	+ 15m 16s	Corr. for 34m	− 2′.9
G. C. T. 4d	11h 33m 54s	Dec. 4d 11h 34m	22° 36′.2 S
S. T. 0h G. T.	18h 47m 18s		
Corr.	1m 54s	R. A. 4d 11h	18h 38m 41s
		Corr. for 34m	+ 1m 20s
G. S. T.	6h 23m 6s		
Long.	+12h 0m 0s	R. A. 4d 11h 34m	18h 40m 1s
L. S. T.	18h 23m 6s	H. P. 57′.0	
Moon's R. A.	18h 40m 1s		
		Time from M. P. 16.9×16.9=286	
Time from M. P.	16m 55s	Table 26 Var. Alt. in 1m=2″.0	
		292×2″=572″	
Obs. Alt.	37° 28′ 14″	Alt. Corr. +9′ 32″	
I. E.	+ 3′ 10″		
	37° 31′ 24″		
Alt. Corr.	+ 9′ 32″		
	37° 40′ 56″		
Corr. (49)	+ 53′ 26″		
h	38° 34′ 22″ S		
	90° 0′ 0″		
Z. D.	51° 25′ 38″ N		
Dec.	22° 36′ 12″ S		
Lat. at Sight	28° 49′ 26″ N		

PROBLEM NO. 3

Sept. 10, 1936. A. M. at ship. Ex-Mer. Alt. Moon's L. L. 54° 38′ 20″ bearing N. Dip 33 ft. Chron. read 9d 21h 39m 28s, which was fast 12m 36s. Lat. by D. R. 12° S. Long. 148° 0′ E. Required latitude at sight?

Chron.	21h 39m 28s
Fast	− 12m 36s
G. C. T. 9d	21h 26m 52s
S. T. 0h G. T.	23h 11m 27s
Corr.	3m 31s
G. S. T.	20h 41m 50s
Long.	+ 9h 52m 0s
L. S. T.	6h 33m 50s
Moon's R. A.	6h 38m 52s
Moon's H. A.	23h 54m 58s
Time from M. P.	5m 2s
Obs. Alt.	54° 38′ 20″
Alt. Corr.	+ 1′ 20″
	54° 39′ 40″
Corr. (49)	+ 42′ 39″
h	55° 22′ 19″ N
	90° 0′ 0″
Z. D.	34° 37′ 41″ S
Dec.	22° 23′ 42″ N
Lat. at Sight	12° 13′ 59″ S

Dec. 9d 21h	22° 25′.9
Corr. for 27m	− 2′.2
Dec. 9d 21h 27m	22° 23′.7 N
R. A. 9d 21h	6h 37m 48s
Corr. for 27m	+ 1m 4s
R. A. 9d 21h 27m	6h 38m 52s

H. P. 57′.4

Time from M. P. $5 \times 5 = 25$
Table 26 Var. Alt. in 1m = 3″.2
$25 \times 3''.2 = 80''$
Alt. Corr. +1′ 20″

PROBLEM NO. 4

March 31, 1936. P. M. at ship. Ex-Mer. Alt. Moon's U. L. 77° 49′ 28″ bearing N. I. E. −4′ 50″. Dip 35 ft. Chron. read 7h 48m 38s P. M., which was fast 6m 29s. Lat. by D. R. 5° N. Long. 0°. Required latitude at sight?

Chron.	19h 48m 38s	Dec. 31d 19h	17° 24′.3
Fast	− 6m 29s	Corr. for 42m	− 7′.3
G. C. T. 31d	19h 42m 9s	Dec. 31d 19h 42m	17° 17′.0 N
S. T. 0h G. T.	12h 32m 45s		
Corr.	3m 14s	R. A. 31d 19h	8h 19m 25s
		Corr. for 42m	+ 1m 34s
G. S. T.	8h 18m 8s		
L. S. T.	8h 18m 8s	R. A. 31d 19h 42m	8h 20m 59s
Moon's R. A.	8h 20m 59s		
		H. P. 55′.6	
Time from M. P.	2m 51s		
		Time from M. P. 2.8×2.8=8	
Obs. Alt.	77° 49′ 28″	Table 26 Var. Alt. in 1m=9″.0	
I. E.	− 4′ 50″	8×9″.0=72″	
	77° 44′ 38″	Alt. Corr. +1′ 12″	
Alt. Corr.	+ 1′ 12″		
	77° 45′ 50″		
Corr. (49)	− 9′ 17″		
h	77° 36′ 33″ N		
	90° 0′ 0″		
Z. D.	12° 23′ 27″ S		
Dec.	17° 17′ 0″ N		
Lat. at Sight	4° 53′ 33″ N		

PROBLEM NO. 5

May 2, 1936. P. M. at ship. Ex-Mer. Alt. Moon's L. L. 53° 28′ 20″ bearing S. I. E. +3′ 50″. Dip 28 ft. Chron. read 2h 49m 35s P. M., which was slow 6m 27s. Lat. by D. R. 32° N. Long. 90° E. Required latitude at sight?

Chron.	14h 49m 35s	
Slow	+ 6m 27s	
G. C. T. 2d	14h 56m 2s	
S. T. 0h G. T.	14h 38m 55s	
Corr.	2m 27s	
G. S. T.	5h 37m 24s	
Long.	+ 6h 0m 0s	
L. S. T.	11h 37m 24s	
Moon's R. A.	11h 45m 7s	
Time from M. P.	7m 43s	
Obs. Alt.	53° 28′ 20″	
I. E.	+ 3′ 50″	
	53° 32′ 10″	
Alt. Corr.	+ 2′ 45″	
	53° 34′ 55″	
Corr. (49)	+ 41′ 0″	
h	54° 15′ 55″ S	
	90° 0′ 0″	
Z. D.	35° 44′ 5″ N	
Dec.	3° 53′ 42″ S	
Lat. at Sight	31° 50′ 23″ N	

Dec. 2d 14h	3° 42′.5
Corr. for 56m	+ 11′.2
Dec. 2d 14h 56m	3° 53′.7 S
R. A. 2d 14h	11h 43m 25s
Corr. for 56m	+ 1m 42s
R. A. 2d 14h 56m	11h 45m 7s
H. P. 54′.0	
Time from M. P. 7.7 × 7.7 = 59	
Table 26 Var. Alt. in 1m = 2″.8	
59 × 2″.8 = 165″	
Alt. Corr. +2′ 45″	

PROBLEM NO. 6

April 20, 1936. A. M. at ship. Ex-Mer. Alt. Moon's U. L. 43° 16′ 30″ bearing N. I. E. +4′ 0″. Dip 40 ft. Chron. read 3h 12m 46s P. M., which was slow 23m 12s. Lat. by D. R. 35° S. Long. 71° W. Required latitude at sight?

Chron.	15h 12m 46s	Dec. 20d 15h	11° 26′.5
Slow	+ 23m 12s	Corr. for 36m	+ 8′.4
G. C. T. 20d	15h 35m 58s	Dec. 20d 15h 36m	11° 34′.9 N
S. T. 0h G. T.	13h 51m 36s		
Corr.	2m 34s	R. A. 20d 15h	0h 56m 56s
		Corr. for 36m	+ 1m 27s
G. S. T.	5h 30m 8s		
Long.	− 4h 44m 0s	R. A. 20d 15h 36m	0h 58m 23s
L. S. T.	46m 8s	H. P. 61′.3	
Moon's R. A.	58m 23s		
		Time from M. P. 12.2×12.2=149	
Time from M. P.	12m 15s	Table 26 Var. Alt. in 1m=2″.2	
		149×2″.2=328″	
Obs. Alt.	43° 16′ 30″	Alt. Corr. +5′ 28″	
I. E.	+ 4′ 0″		
	43° 20′ 30″		
Alt. Corr.	+ 5′ 28″		
	43° 25′ 58″		
Corr. (49)	+ 20′ 29″		
h	43° 46′ 27″ N		
	90° 0′ 0″		
Z. D.	46° 13′ 33″ S		
Dec.	11° 34′ 54″ N		
Lat. at Sight	34° 38′ 39″ S		

CHAPTER XXXV

DEVIATION BY FIXED STAR, PLANET AND MOON

The method of determining deviation by celestial bodies other than the sun becomes imperative in certain localities where variation is changing quickly, and climatic conditions are such that observations of the sun are not available at all times, also when navigating in dangerous waters. Therefore this method should be thoroughly understood by all navigators.

RULE:

1. Find the Greenwich Civil Time (G. C. T.).
2. Find the Greenwich Siderial Time (G. S. T.) as follows:
   Add together G. C. T., Siderial Time 0h Greenwich Time (S. T. 0h G. T.) and correction from table on page 2 (N. A.) for G. C. T.
3. Find the Local Siderial Time (L. S. T.) as follows:
   From the G. S. T. subtract the longitude if West, add if East.
4. Find the body's hour angle (H. A.) as follows:
   From the L. S. T. subtract the observed body's right ascension (R. A.).
5. Enter azimuth table with latitude to nearest degree, declination to nearest degree at top, and body's H. A. at side in the P. M. column, and take out azimuth or true bearing.

   NOTE.—If the declination exceeds 23° it is necessary to use "Azimuths of Celestial Bodies" H. O. 120, from declination 24° to 70°. In using H. O. 120 when the latitude and declination are of the same name, the azimuth is read from N to E or from N to W in north latitude, and from S to E and from S to W in south latitude. When latitude and declination are contrary names, it is necessary to

enter the table with the supplement of the hour angle.

For example: H. A. 7h 50m. Supplement is 12h − 7h 50m = 4h 10m, which is H. A. to enter table with.

The supplement of the azimuth found with this H. A. is the true azimuth.

For example: Lat. 37° N. Decl. 28° S. H. A. 8h 20m body bearing West. Required true azimuth?

12h − 8h 20m = 3h 40m Supp. H. A.

Lat. 37° Decl. 28° H. A. 3h 40m = Az. from table 84° 28′

180° − 84° 28′ = True bearing N 95° 32′ W.

6. The true bearing and compass bearing are applied to each other, and the compass error and deviation found by same rule as in azimuth of sun.

PROBLEM NO. 1

May 9, 1936. A. M. at ship. Lat. 59° 48′ N. Long. 30° 42′ E. Compass bearing *Arcturus S 56° W. Chron. read 0h 39m 12s A. M. (correct). Variation 12° E. Required error and deviation of compass?

G. C. T. 9d	0h 39m 12s	Dec.	19° 30′.6 N	
S. T. 0h G. T.	15h 6m 31s			
Corr.	6s	Az. Lat. 60° N. Dec. 20° N.		
		H. A. 3h 36m =		
G. S. T.	15h 45m 49s	True Bearing	N 112°	0′ W
Long.	+ 2h 2m 48s	Comp. Bearing	N 124°	0′ W
L. S. T.	17h 48m 37s	Compass Error	12°	0′ E
*R. A.	−14h 12m 47s	Variation	12°	0′ E
*H. A.	3h 35m 50s	Deviation	0°	

PROBLEM NO. 2

June 12, 1936. P. M. at ship. Lat. 31° 15′ N. Long. 47° 38′ W. Chron. read 9h 18m 28s P. M., which was slow 11m 42s. Compass bearing *Adhara N 116° 30′ W. Variation 23° W. Required error and deviation of compass?

Chron.	21h 18m 28s
Slow	+ 11m 42s
G. C. T. 12d	21h 30m 10s
S. T. 0h G. T.	17h 20m 34s
Corr.	3m 32s
G. S. T.	14h 54m 16s
Long.	− 3h 10m 32s
L. S. T.	11h 43m 44s
*R. A.	6h 56m 7s
*H. A.	4h 47m 37s
	12h 0m 0s
Supp. H. A.	7h 12m 23s

Dec. 28° 53′.2 S

Az. Lat. 31° N. Dec. 29° S. H. A. 7h 12m = 56° 18′.

180 − 56° 18′ =

True Bearing	N 123° 42′ W
Comp. Bearing	N 116° 30′ W
Compass Error	7° 12′ W
Variation	23° 0′ W
Deviation	15° 48′ E

PROBLEM NO. 3

June 15, 1936. P. M. at ship. Lat. 21° 14′ S. Long. 135° W. Chron. read 11h 49m 38s P. M., which was slow 4m 38s. Compass bearing Planet Venus S 121° 15′ W. Variation 9° W. Required error and deviation?

Chron.	23h 49m 38s
Slow	+ 4m 38s
G. C. T. 15d	23h 54m 16s
S. T. 0h G. T.	17h 32m 23s
Corr.	3m 56s
G. S. T.	17h 30m 35s
Long.	− 9h 0m 0s
L. S. T.	8h 30m 35s
*R. A.	5h 18m 43s
*H. A.	3h 11m 52s

Dec. 15d 23h 54m 23° 8′.0 N

R. A. 15d 0h	5h 15m 25s
Corr. for 23h 54m	+ 3m 18s
R. A. 15d 23h 54m	5h 18m 43s

Lat. 21° S. Dec. 23° N. H. A. 3h 12m = Az. 130° 34′ = True Bearing.

True Bearing	S 130° 34′ W
Compass Bearing	S 121° 15′ W
Compass Error	9° 19′ E
Variation	9° 0′ W
Deviation	18° 19′ E

PROBLEM NO. 4

May 6, 1936. P. M. at ship. Lat. 32° 10′ N. Long. 85° E. Chron. read 1h 13m 12s P. M., which was slow 3m 49s. Compass bearing Planet Mars N 88° 45′ W. Variation 1° 30′ W. Required error and deviation of compass?

Chron.	13h 13m 12s	Dec. 6d 0h	19° 11′.5
Slow	+ 3m 49s	Corr. for 13h 17m	+ 6′.0
G. C. T. 6d	13h 17m 1s	Dec. 6d 13h 17m	19° 17′.5 N
S. T. 0h G. T.	14h 54m 41s		
Corr.	2m 11s	R. A. 6d 0h	3h 29m 23s
		Corr. for 13h 17m	+ 1m 37s
G. S. T.	4h 13m 53s		
Long.	+ 5h 40m 0s	R. A. 6d 13h 17m	3h 31m 0s
L. S. T.	9h 53m 53s	Lat. 32° N. Dec. 19° N. H. A. 6h 23m = Az.	
*R. A.	3h 31m 0s	True Bearing	N 70° 53′ W
*H. A.	6h 22m 53s	Compass Bearing	N 88° 45′ W
		Compass Error	17° 52′ E
		Variation	1° 30′ W
		Deviation	19° 22′ E

PROBLEM NO. 5

July 13, 1936. A. M. at ship. Lat. 39° 12′ N. Long. 175° 47′ W. Chron. read 3h 14m 28s P. M., slow 7m 18s. Moon bore by compass N 116° E. Variation 12° E. Required error and deviation of compass?

Chron.	15h 14m 28s	Dec. 13d 15h	20° 30′.3
Slow	+ 7m 18s	Corr. for 22m	+ 2′.9
G. C. T. 13d	15h 21m 46s	Dec. 13d 15h 22m	20° 33′.2 N
S. T. 0h G. T.	19h 22m 47s		
Corr.	2m 32s	R. A. 13d 15h	2h 52m 14s
		Corr. for 22m	+ 54s
G. S. T.	34h 47m 5s		
Long.	−11h 43m 8s	R. A. 13d 15h 22m	2h 53m 8s
L. S. T.	23h 3m 7s	Lat. 39° N. Dec. 21° N. H. A. 3h 50m = Az.	
Moon's R. A.	− 2h 53m 8s		
Moon's H. A.	20h 9m 59s	True Bearing	N 92° 42′ E
	24h 0m 0s	Compass Bearing	N 116° 0′ E
H. A.	3h 50m 1s	Compass Error	23° 18′ W
		Variation	12° 0′ E
		Deviation	35° 18′ W

PROBLEM NO. 6

Oct. 12, 1936. A. M. at ship. Lat. 28° 49′ S. Long. 90° E. Chron. read 0h 8m 3s A. M., which was slow 12m 26s. Moon bore by compass S 116° E. Variation 4° 15′ W. Required error and deviation of compass?

Chron.		0h 8m 3s	Dec. 12d 0h		3° 4′.9
Slow	+	0h 12m 26s	Corr. for 20m	−	4′.1
G. C. T. 12d		0h 20m 29s	Dec. 12d 0h 20m		3° 0′.8 N
S. T. 0h G. T.		1h 21m 33s			
Corr.		3s	R. A. 12d 0h		10h 41m 27s
			Corr. for 20m	+	37s
G. S. T.		1h 42m 5s			
Long.	+	6h 0m 0s	R. A. 12d 0h 20m		10h 42m 4s
L. S. T.		7h 42m 5s	Lat. 29° S. Dec. 3° N. H. A. 3h 0m = Az.		
Moon's R. A.		10h 42m 4s			
Moon's H. A.		2h 59m 59s	True Bearing		S 118° 48′ E
			Compass Bearing		S 116° 0′ E
			Compass Error		2° 48′ W
			Variation		4° 15′ W
			Deviation		1° 27′ E

CHAPTER XXXVI

LONGITUDE AT SUNRISE AND SUNSET

This problem is to find the longitude when the sun's upper or lower limb just touches the horizon at sunrise or sunset.

It is only necessary to use a pair of marine glasses for this observation, and the chronometer must be read at instant of contact with horizon.

As it is very doubtful that a proper contact with sun and horizon has been noted, this observation is not to be entirely relied upon, but the navigator should understand it, as it is often the case that he does not get any sights during the day, and the sun sets in the clear. He can then get a fairly good idea of his longitude from this problem.

RULE:

1. Find the G. C. T. and date.
2. Find the G. A. T. and date.
3. Correct sun's declination for G. C. T., and find polar distance.
4. Add together latitude and polar distance.
5. Find the negative altitude as follows:
   If the lower limb is observed:
   Add together Mean Refraction (20 A) and Dip (14). Sum of these two will be named minus (−).
   Add together Parallax (16) and Semi-Diameter (N. A.). Sum of these will be named plus (+).
   Subtract these two quantities, and the result will be the negative altitude (−).
   If the upper limb is observed:
   Add together semi-diameter, dip and refraction, and subtract from this sum the parallax, result will be negative altitude (−).
6. From the sum of the latitude and polar distance, subtract the negative, altitude.
7. Divide this result by 2, and obtain half sum.

8. To the half sum, add the negative altitude. Result will be remainder.
9. From Table 44 take out following logs.:
   Secant of latitude.
   Cosecant of polar distance.
   Cosine of half sum.
   Sine of remainder.
   Add these four logs. together.
10. Log. Hav. of sum of logs. will be L. A. T.
11. If observation was at sunrise, L. A. T. is read from bottom of page, subtracting 12 from the hours. If it was sunset, read from top of page.
12. Apply L. A. T. and G. A. T., and the result will be longitude.

NOTE.—Many navigators use in this problem a negative altitude of $-21'$ for lower limb observations, and $-53'$ for upper limb observations. This would be correct if there was no dip, but in the present-day steamship of great height above sea level it is much more accurate to compute the negative altitude.

PROBLEM NO. 1

Jan. 11, 1936. Sun's L. L. at sunset observed. Chron. read 11h 3m 12s A. M., which was slow on Dec. 6, 15m 28s and gaining 4s.7 daily. Lat. 18° 14′ N. Dip 38 ft. Required longitude?

Chron.	11h 3m 12s	Interval 36.5 days	
Slow	+ 15m 28s	D. R. 4s.7 × 36.5 = 172s	
	11h 18m 40s	Acc. Rate 2m 52s gaining	
Acc. Rate	− 2m 52s	Dec. 11d 10h	21° 57′.3
G. C. T. 11d	11h 15m 48s	Corr. for 1.3h	− .5
Eq. Time	− 7m 41s	Dec. 11d 11.3h	21° 56′.8 S
			+90° 0′.0
G. A. T. 11d	11h 8m 7s	P. D.	111° 56′.8

Lat.	18° 14′ 0″	Sec	.02237		
P. D.	111° 56′ 48″	Csc	.03267	Ref.	36′ 29″
				Dip	6′ 2″
	130° 10′ 48″				
Neg. Alt.	− 26′ 4″				−42′ 31″
	2)129° 44′ 44″				+16′ 27″
s	64° 52′ 22″	Cos	9.62801		
Neg. Alt.	+ 26′ 4″			N. Alt.	−26′ 4″
Rem.	65° 18′ 26″	Sin	9.95835	S. D.	16′ 18″
				Par.	9″
		Log. Hav.	9.64140		+16′ 27″
L. A. T. 11d	17h 31m 28s				
G. A. T. 11d	11h 8m 7s				
Long.	6h 23m 21s	or	95° 50′ 15″ E		

PROBLEM NO. 2

Feb. 23, 1936. Sun's U. L. at sunset observed. Chron. read 11h 18m 26s P. M., which was slow on Jan. 10, 58m 12s and losing 7s.2 daily. Lat. 29° 28′ N. Dip 32 ft. Required longitude?

Chron.	23h 18m 26s	Interval 45 days			
Slow	+ 58m 12s	D. R. 7s.2×45=324s			
		Acc. Rate 5m 24s losing			
	0h 16m 38s				
Acc. Rate	+ 5m 24s	Dec. 24d 0h		9° 58′.0	
		Corr. for .4h		− .4	
G. C. T. 24d	0h 22m 2s				
Eq. Time	− 13m 34s	Dec. 24d 0.4h		9° 57′.6 S	
				+90° 0′.0	
G. A. T. 24d	0h 8m 28s				
		P. D.		99° 57′.6	
Lat.	29° 28′ 0″	Sec	.06016		
P. D.	99° 57′ 36″	Csc	.00659	Ref.	36′ 29″
				Dip	5′ 33″
	129° 25′ 36″			S. D.	16′ 11″
Neg. Alt.	− 58′ 4″				
	2)128° 27′ 32″				−58′ 13″
s	64° 13′ 46″	Cos	9.63826	Par.	+ 9″
Neg. Alt.	+ 58′ 4″				
				N. Alt.	−58′ 4″
Rem.	65° 11′ 50″	Sin	9.95797		
		Log. Hav.	9.66298		
L. A. T. 23d	17h 41m 45s				
G. A. T. 24d	0h 8m 28s				
Long.	6h 26m 43s	or	96° 40′ 45″ W		

PROBLEM NO. 3

April 24, 1936. Sun's L. L. at sunrise observed. Chron. read 0h 16m 18s A. M., which was slow on April 3, 18m 2s and gaining 4s.6 daily. Lat. 23° 10′ S. Dip 48 ft. Required longitude?

Chron.		0h 16m 18s	Interval 21 days		
Slow	+	18m 2s	D. R. 4s.6×21 = 97s		
			Acc. Rate 1m 37s gaining		
		0h 34m 20s			
Acc. Rate	−	1m 37s	Dec. 24d 0h		12° 44′.0
			Corr. for .5h	+	.4
G. C. T. 24d		0h 32m 43s			
Eq. Time	+	1m 47s	Dec. 24d 0.5h		12° 44′.4 N
					+90° 0′.0
G. A. T. 24d		0h 34m 30s			
			P. D.		102° 44′.4

Lat.		23° 10′ 0″	Sec	.03651	S. D.	15′ 56″
P. D.		102° 44′ 24″	Csc	.01082	Par.	9″
		125° 54′ 24″				+16′ 5″
Neg. Alt.	−	27′ 12″				
	2)	125° 27′ 12″			Ref.	36′ 29″
s		62° 43′ 36″	Cos	9.66109	Dip	6′ 48″
Neg. Alt.	+	27′ 12″				−43′ 17″
Rem.		63° 10′ 48″	Sin	9.95057		+16′ 5″
L. A. T. 24d		6h 20m 11s	Log. Hav.	9.65899	N. Alt.	−27′ 12″
G. A. T. 24d		0h 34m 30s				
Long.		5h 45m 41s	or 86° 25′ 15″ E			

PROBLEM NO. 4

May 6, 1936. Sun's U. L. at sunrise observed. Chron. read 1h 12m 10s P. M., which was slow on April 21, 3m 18s and losing 3s.6 daily. Lat. 19° 18′ S. Dip 52 ft. Required longitude?

Chron.		13h 12m 10s	Interval 15.5 days		
Slow	+	3m 18s	D. R. 3s.6×15.5 = 56s		
			Acc. Rate 56s losing		
		13h 15m 28s			
Acc. Rate	+	56s	Dec. 6d 12h		16° 33′.9
			Corr. for 1.3h	+	.9
G. C. T. 6d		13h 16m 24s			
Eq. Time	+	3m 27s	Dec. 6d 13.3h		16° 34′.8 N
					+90° 0′.0
G. A. T. 6d		13h 19m 51s			
			P. D.		106° 34′.8

Lat.	19° 18′ 0″	Sec	.02512	Ref.	36′ 29″
P. D.	106° 34′ 48″	Csc	.01844	Dip	7′ 4″
				S. D.	15′ 53″
	125° 52′ 48″				
Neg. Alt.	− 59′ 17″				−59′ 26″
	2)124° 53′ 31″			Par.	+ 9″
s	62° 26′ 45″	Cos	9.66519		
Neg. Alt.	+ 59′ 17″			N. Alt.	−59′ 17″
Rem.	63° 26′ 2″	Sin	9.95154		
L. A. T. 6d	6h 19m 33s	Log. Hav.	9.66029		
G. A. T. 6d	13h 19m 51s				
Long.	7h 0m 18s	or	105° 4′ 30″ W		

PROBLEM NO. 5

June 12, 1936. Sun's L. L. at sunset observed. Chron. read 13d 1h 15m 16s, which was fast on May 6, 13m 14s and losing 6s.3 daily. Lat. 42° 10′ S. Dip 43 ft. Required longitude?

Chron.	1h 15m 16s		Interval 38 days		
Fast	− 13m 14s		D. R. 6s.3 × 38 = 239s		
			Acc. Rate 3m 59s losing		
	1h 2m 2s				
Acc. Rate	+ 3m 59s		Dec. 13d 0h	23° 11′.6	
			Corr. for 1.1h	+ .2	
G. C. T. 13d	1h 6m 1s				
Eq. Time	+ 15s		Dec. 13d 1.1h	23° 11′.8 N	
				+90° 0′.0	
G. A. T. 13d	1h 6m 16s				
			P. D.	113° 11′.8	
Lat.	42° 10′ 0″	Sec	.13007	S. D.	15′ 47″
P. D.	113° 11′ 48″	Csc	.03661	Par.	9″
	155° 21′ 48″				+15′ 56″
Neg. Alt.	− 27′ 0″				
	2)154° 54′ 48″				
s	77° 27′ 24″	Cos	9.33681	Ref.	36′ 29″
Neg. Alt.	+ 27′ 0″			Dip	6′ 27″
Rem.	77° 54′ 24″	Sin	9.99025		−42′ 56″
					+15′ 56″
L. A. T. 12d	16h 31m 30s	Log. Hav.	9.49374		
L. A. T. 13d	1h 6m 16s			N. Alt.	−27′ 0″
Long.	8h 34m 46s	or	128° 41′ 30″ W		

PROBLEM NO. 6

July 14, 1936. Sun's U. L. at sunset observed. Chron. read 11h 12m 18s A. M., which was fast on June 12, 6m 36s and losing 3s.2 daily. Lat. 42° 10′ N. Dip 24 ft. Required longitude?

Chron.	11h 12m 18s	Interval 32.5 days	
Fast	− 6m 36s	D. R. 3s.2 × 32.5 = 104s	
	11h 5m 42s	Acc. Rate 1m 44s losing	
Acc. Rate	+ 1m 44s	Dec. 14d 10h	21° 41′.4
G. C. T. 14d	11h 7m 26s	Corr. for 1.1h	− .4
Eq. Time	− 5m 40s	Dec. 14d 11.1h	21° 41′.0 N
G. A. T. 14d	11h 1m 46s		−90° 0′.0
		P. D.	68° 19′.0

Lat.	42° 10′ 0″	Sec	.13007	Ref.	36′ 29″
P. D.	68° 19′ 0″	Csc	.03187	Dip	4′ 48″
				S. D.	15′ 46″
	110° 29′ 0″				
Neg. Alt	− 56′ 54″				−57′ 3″
	2)109° 32′ 6″			Par.	+ 9″
s	54° 46′ 3″	Cos	9.76110	N. Alt.	56′ 54″
Neg. Alt	+ 56′ 54″				
Rem.	55° 42′ 57″	Sin	9.91711		
L. A. T. 14d	19h 30m 22s	Log. Hav.	9.84015		
G. A. T. 14d	11h 1m 46s				
Long.	8h 28m 36s	or	127° 9′ 0″ E		

CHAPTER XXXVII

TIME OF HIGH WATER

This problem is to find the time of high water at any given port.

The most expeditious, as well as the most exact, method of ascertaining the times of high water and other features of the tides will be by reference to a Tide Table, and every navigator is recommended to provide himself with such a publication.

Where no tide tables are available, the following rules and examples may be followed, but it must be understood that the results found are approximate.

RULE:

1. From Bowditch Appendix IV (pages 303–404) take out approximate longitude of place to nearest degree, and lunar interval for high water.
2. Determine the longitude of the Standard Time used in the locality.
3. Multiply longitude of station by 4.14, and longitude of standard time by 4, and subtract less from greater.
4. In West Longitude:
   If product of longitude of station is greater than product of longitude of standard time, add the difference to lunitidal interval.
   If product of longitude of station is less than product of longitude of standard time, subtract the difference from lunitidal interval.
5. In East Longitude:
   The reverse of Rule 4 prevails.
6. Add this modified lunitidal interval to the Moon's Transit (pages 134–135 N. A.) and the result will be Standard Time of High Water A. M. or P. M.

7. If A. M. High Water is found, multiply the variation per hour by 12 hours, and add. The result will be P. M. High.

If P. M. is found, subtract the variation in 12 hours, and the result will be A. M. High Water.

PROBLEM NO. 1

April 15, 1936. Find time of high water at New York Navy Yard?

H. W. Interval 8h 44m
74° × 4.14 = 306.36
75° × 4 = 300.00

Correction + 6.36

Long. of Standard Time 75° W

Moon's Var. per hour
2.2m × 12h = 26 m

H. W. Interval		8h 44m
Correction	+	6m
Modified H. W. Int.		8h 50m
Moon's Transit 15d		6h 33m
High Water 15d		15h 23m or 3h 23m P. M. (75th Meridian Time)
Moon's change in transit for 12h	−	26m
High Water 15d		2h 57m A. M. (75th Meridian Time)

PROBLEM NO. 2

Feb. 17, 1936. Find time of high water at the Presidio, San Francisco?

H. W. Interval 11h 43m
Approx. Long. of Station 122° W
122° × 4.14 = 505.08
120° × 4 = 480.00

Correction + 25.08 m

Long. of Standard Time 120° W

Moon's Var. per hour
2.3m × 12h = 28m

H. W. Interval		11h 43m
Correction	+	25m
Modified H. W. Int.		12h 8m
Moon's Transit 17d		7h 16m
High Water 17d		19h 24m or 7h 24m P. M. (120th Meridian Time)
Moon's change in transit for 12 h	−	28m
High Water 17d		6h 56m A. M. (120th Meridian Time)

PROBLEM NO. 3

April 18, 1936. Find time of high water at Singapore?

H. W. Interval 10h 20m — Long. of Standard Time 105° E
Approx. Long. of Station 104° E
104° × 4.14 = 430.56
105° × 4 = 420.00

Correction − 10.56 m — Moon's Var. per hour
H. W. Interval 10h 20m — 2.1 × 12h = 25m
Correction − 11m

Modified H. W. Int. 10h 9m
Moon's Transit 18d 9h 7m

High Water 18d 19h 16m or 7h 16m P. M. (105th Meridian Time)
Moon's change in transit for 12h − 25m

High Water 18d 6h 51m A. M. (105th Meridian Time)

PROBLEM NO. 4

June 16, 1936. Find time of high water at Gibraltar?

H. W. Interval 1h 35m — Long. of Standard Time 0°
Approx. Long. of Station 5° W
5° × 4.14 = Correction +20h 7m — Moon's Var. per hour
H. W. Interval 1h 35m — 2.4m × 12h = 29m
Correction + 21m

Modified H. W. Interval 1h 56m
Moon's Transit 16d 9h 16m

High Water 16d 11h 12m A. M. (Greenwich Time)
Moon's change in transit for 12h + 29m

High Water 16d 11h 41m P. M. (Greenwich Time)

CHAPTER XXXVIII

NOON INTERVAL

(H. O. No. 202)

RULE:

1. Enter Table 2 (Bowditch) with course, and hourly speed of ship in distance column, and take out departure.
2. With middle latitude to nearest degree as a course, enter Table 2 and look for departure in latitude column, and in the distance column will be found difference of longitude. This will give hourly difference of longitude.
3. With hourly difference of longitude on side of page and L. A. T. at top look in H. O. 202 (Noon Interval Tables) and take out interval to noon expressed in hours, minutes and seconds; and also hours and decimals of hours.
4. To ship's time add hours, minutes and seconds found in table. The difference of that sum and 12 hours will give the change to be made in ship's clock for correct noon.
5. Multiply hours and decimals of hours by speed of ship. This will give distance run in interval.

EXAMPLE:

Feb. 9, 1936. Ship's time 8h 0m 2s. Lat. 38° N. L. A. T. was found by observation to be 8h 17m 30s. Speed of ship 11.5 knots. Course 66° (true). Find the interval and the distance run to noon, and also change to be made in ship's clock?

Course 66° Speed of ship 11.5 Table 2 = Dep. 10.5
Mid. Lat. 38° Departure 10.5 Table 2 = Hrly. D. Lon. 13.3
Noon Interval Table L. A. T. 8h 17m 30s. Hrly. Diff. Lon. 13.3 =

h	m	s	Hours
3	39	16	3.6543, thence:

Ship's Time 8h 0m 2s + 3h 39m 16s = 11h 39m 18s
− 12h 0m 0s

Change to be made in clock for correct noon − 20m 42s
Speed of ship 11.5 × 3.6543 hours = 42.02445 miles run in interval.

CHAPTER XXXIX

SUMNER'S METHOD WITH TWO ASSUMED LATITUDES

This method of finding the ship's position by Sumner lines is the original method discovered by Capt. Sumner. On account of it being necessary in this problem to work out four separate observations for longitude, it is not used as much as formerly, but it should be understood by all students of navigation.

The great advantage to the navigator in Sumner lines is in the fact that he can determine the ship's position immediately by computation or by plotting the lines on a chart if two heavenly bodies are visible at the same time, which are nearly at right angles or 90° from each other. If one body only is visible, he can determine his position by allowing the body to change its bearing about 30°, allowing for the course and distance run in interval between observations.

RULE:

1. Take an observation of heavenly body, and find the longitude that each assumed latitude will give.
2. Place these two positions on the chart and connect them with a line.
   This will be named the First Position Line, and the ship will be somewhere on this line at time of observation.
3. *In case of the sun observed:*
   After the sun has changed its bearing 30° or more, take another observation, and find the longitude that the same two assumed latitudes will give.
4. Place these two positions on the chart, and connect them with a line.
   This will be named the Second Position Line, and the ship will be somewhere on this line at time of Second Observation.
5. From the First Position Line allow the true course and distance the ship has run between observa-

tions, and draw a line through this point parallel to the First Position Line.

This will be named the First Position Line projected.

6. Where the First Position Line projected crosses the Second Position Line will be the ship's position at time of Second Observation.

7. *In case of simultaneous observations:*
Find the longitude that each assumed latitude will give for First Body, and connect these two positions with a line.
This will give First Position Line.

8. Find the longitude that each assumed latitude will give for Second Body, and connect these two positions with a line.
This will give Second Position Line.

9. Where the First and Second Position Lines cross each other will be the ship's position.

By the assumed latitude method the Sumner lines can be proven from azimuth table as follows: If the Position Lines are at right angles, or 90° from true azimuth, the lines are correct.

PROBLEM NO. 1

TWO OBSERVATIONS OF THE SUN

March 4, 1936. At 7.30 A. M. at ship. When not sure of position an obs. alt. of sun's L. L. was 13° 21′ 45″. Chron. read 12h 15m 25s P. M., which was slow 2m 8s. Dip 36 ft.

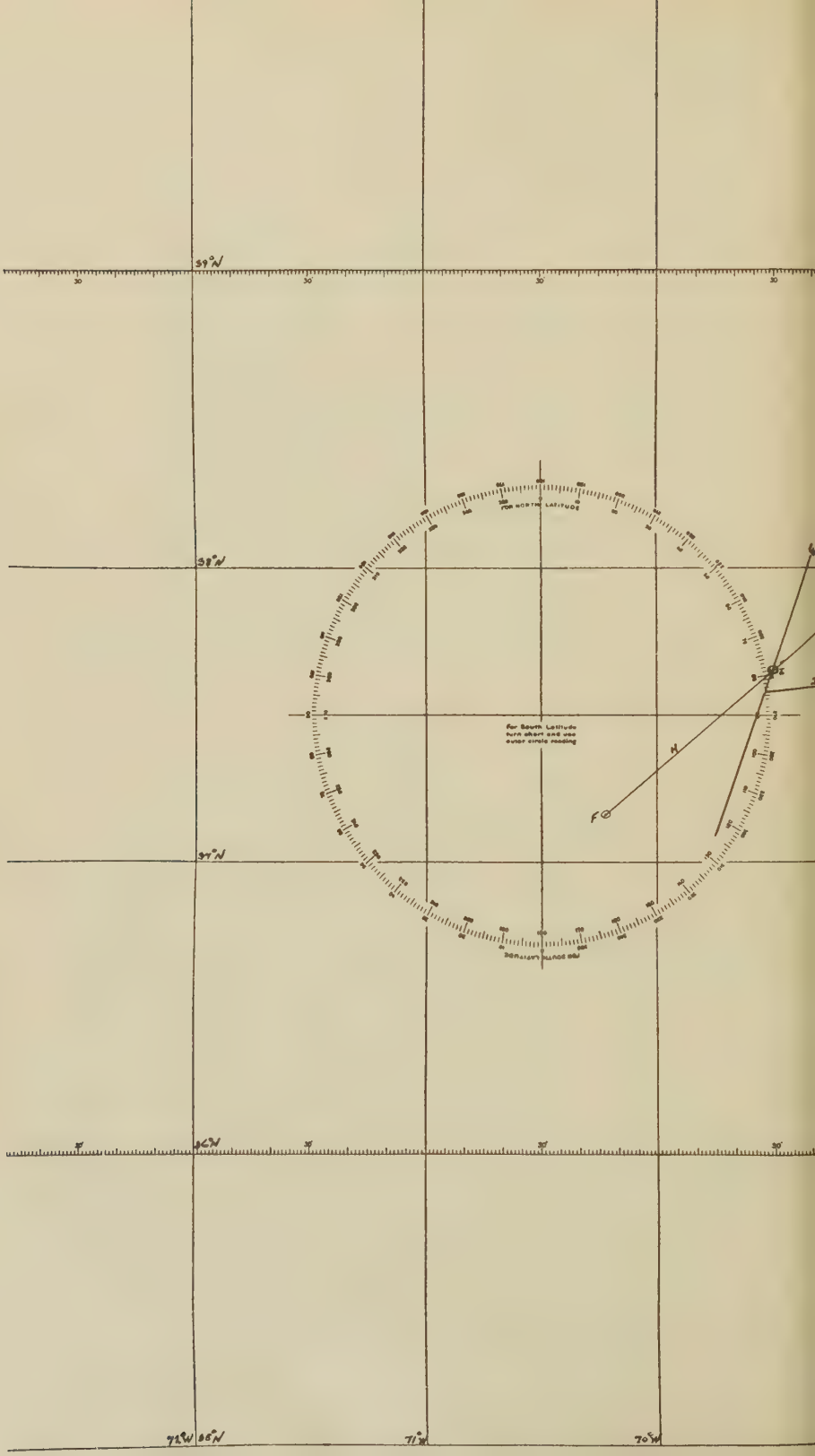
At 10 A. M. Obs. Alt. Sun's L. L. 37° 23′. Chron. read 2h 45m P. M. Ship ran between observations S 84° W (true) 12 knots per hour.

Ship was assumed to be between the latitudes of 37° 10′ N and 37° 50′ N.

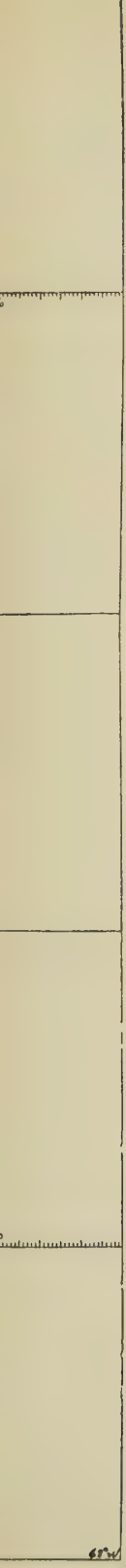
Required position of vessel at Second Observation?

First Observation

Chron.	12h 15m 25s	Dec. 4d 12h	6° 23′.4
Slow	+ 2m 8s	Corr.for .3h	− .3
G. C. T. 4d	12h 17m 33s	Dec. 4d 12.3h	6° 23′.1 S
Eq. Time	− 12m 5s		+90° 0′.0
G. A. T. 4d	12h 5m 28s	P. D.	96° 23′.1



39°N
38°N
37°N
36°N
72°W
71°W
70°W
FOR NORTH LATITUDE
For South Latitude
turn chart and use
outer circle reading
H
F



Latitudes

Problem No. 1

A. Lat. 37° 10′ N Long. 69° 6′ W.
B. Lat. 37° 50′ N Long. 68° 48′ 15″ W.
C. 1st Position line, at right angles to sun's true bearing, or N 19° E.
D. Course and distance run between observations S 84° W 30 miles.
E. 1st Position line projected for course and distance.
F. Lat. 37° 10′ N Long. 70° 13′ 30″ W.
G. Lat. 37° 50′ N Long. 69° 13′ 30″ W.
H. 2d Position line, at right angles to sun's true bearing, or N 50° E.
I. Position of vessel at 2d observation Lat. 37° 39′ 30″ N Long. 69° 29′ 30″ W.

Obs. Alt.	13° 21′ 45″		
Corr. (46)	+ 6′ 23″		
h	13° 28′ 8″		
Lat.	37° 10′ 0″	Sec	.09861
P. D.	96° 23′ 6″	Csc	.00270
	2)147° 1′ 14″		
s	73° 30′ 37″	Cos	9.45308
s−h	60° 2′ 29″	Sin	9.93771

Log. Hav. 9.49210 = L. A. T. 4d 7h 29m 4s
G. A. T. 4d 12h 5m 28s

Long. T. 4h 36m 24s
Long. 69° 6′ W

h	13° 28′ 8″		
Lat.	37° 50′ 0″	Sec	.10248
P. D.	96° 23′ 6″	Csc	.00270
	2)147° 41′ 14″		
s	73° 50′ 37″	Cos	9.44446
s−h	60° 22′ 29″	Sin	9.93915

Log. Hav. 9.48879 = L. A. T. 4d 7h 30m 15s
G. A. T. 4d 12h 5m 28s

Long. T. 4h 35m 13s
Long. 68° 48′ 15″ W

First Observation

Lat. 37° 10′ N. Long. 69° 6′ W.
Lat. 37° 50′ N. Long. 68° 48′ 15″ W.

Place these two positions on chart, and connect them with line; this will be First Position Line, which is at right angles to sun's true bearing.

Allow from any place on this line the course and distance run between observations, or a true course of S 84° W distance 30 miles, and through this point draw a line parallel to First Position Line. This will be the First Position Line projected for course and distance.

Second Observation

Chron.	14h 45m 0s	Dec. 4d 14h	6° 21′.5
Slow	+ 2m 8s	Corr. for .8h	− .8
G. C. T. 4d	14h 47m 8s	Dec. 4d 14.8h	6° 20′.7 S
Eq. Time	− 11m 50s		+90° 0′.0
G. A. T. 4d	14h 35m 18s	P. D.	96° 20′.7

Obs. Alt.	37° 23′ 0″		
Corr. (46)	+ 9′ 7″		
h	37° 32′ 7″		
Lat.	37° 10′ 0″	Sec	.09861
P. D.	96° 20′ 42″	Csc	.00̇267
	2)171° 2′ 49″		
s	85° 31′ 24″	Cos	8.89239
s − h	47° 59′ 17″	Sin	9.87099

Log. Hav. 8.86466 = L. A. T. 4d 9h 54m 24s
G. A. T. 4d 14h 35m 18s

Long. T. 4h 40m 54s
Long. 70° 13′ 30″ W

h	37° 32′ 7″		
Lat.	37° 50′ 0″	Sec	.10248
P. D	96° 20′ 42″	Csc	.00267
	2)171° 42′ 49″		
s	85° 51′ 24″	Cos	8.85885
s − h	48° 19′ 17″	Sin	9.87325

Log. Hav. 8.83725 = L. A. T. 4d 9h 58m 24s
G. A. T. 4d 14h 35m 18s

Long. T. 4h 36m 54s
Long. 69° 13′ 30″ W

Second Observation

Lat. 37° 10′ N. Long. 70° 13′ 30″ W.
Lat. 37° 50′ N. Long. 69° 13′ 30″ W.

Place these two positions on chart and connect them with line. This will be Second Position Line.

Where the Second Position Line crosses the projection of the First Position Line will be the ship's position at Second Observation.

See: Chartlet following this problem.
Sumner "Tangent" Method, Problem 1.
Marcq St. Hilaire Method, Problem 1.
Double's Chronometer Method, Problem 1.
H. O. 211 and 208, Problem 1.

PROBLEM NO. 2

SIMULTANEOUS OBSERVATIONS OF TWO FIXED STARS

Dec. 6, 1936. A. M. at ship. When not sure of position an obs. alt. of *Regulus bearing W was 48° 41′. Dip 26 ft. Chron. read 7h 17m 15s A. M., which was slow 14m 6s. Immediately after an obs. alt. *Arcturus bearing E was 46° 32′ 30″. Chron. read 7h 18m 37s.

Ship was assumed to be between the latitudes of 49° 10′ N and 49° 50′ N.

Required position of vessel at Second Observation?

First Observation, Regulus W

Chron.	7h 17m 15s	Dec.			12° 16′.5 N
Slow	+ 14m 6s				−90° 0′.0
G. C. T. 6d	7h 31m 21s	P. D.			77° 43′.5
S. T. 0h G. T.	4h 58m 24s				
Corr.	1m 14s				
G. S. T.	12h 30m 59s				
Obs. Alt.	48° 41′ 0″				
Corr. (46)	− 5′ 50″			R. A.	10h 5m 2s
				H. A.	+ 1h 31m 6s
h	48° 35′ 10″				
Lat.	49° 10′ 0″	Sec	.18451	L. S. T.	11h 36m 8s
P. D.	77° 43′ 30″	Csc	.01005	G. S. T.	12h 30m 59s
	2)175° 28′ 40″				
s	87° 44′ 20″	Cos	8.59608	Long. T.	54m 51s
s−h	39° 9′ 10″	Sin	9.80030	Long.	13° 42′ 45″ W
		Log. Hav.	8.59094	= H. A.	

				R. A.	10h 5m 2s
h	48° 35′ 10″			H. A.	+ 1h 24m 56s
Lat.	49° 50′ 0″	Sec	.19043		
P. D.	77° 43′ 30″	Csc	.01005	L. S. T.	11h 29m 58s
	2)176° 8′ 40″			G. S. T.	12h 30m 59s
s	88° 4′ 20″	Cos	8.52685		
s−h	39° 29′ 10″	Sin	9.80339	Long. T.	1h 1m 1s
				Long.	15° 15′ 15″ W
		Log. Hav.	8.53072	= H. A.	

First Observation

Lat. 49° 10′ N. Long. 13° 42′ 45″ W.

Lat. 49° 50′ N. Long. 15° 15′ 15″ W.

Place these two positions on chart and connect them with line. This will be First Position Line, which is at right angles to star's true bearing.

Second Observation, Arcturus E

Chron.	7h 18m 37s	Dec.	19° 30′.5 N
Slow	+ 14m 6s		−90° 0′.0
G. C. T. 6d	7h 32m 43s	P. D.	70° 29′.5
S. T. 0h G. T.	4h 58m 24s		
Corr.	1m 14s		
G. S. T.	12h 32m 21s		

Obs. Alt.	46° 32′ 30″			R. A.	14h 12m 47s
Corr. (46)	− 5′ 55″			H. A.	− 2h 40m 4s
h	46° 26′ 35″			L. S. T.	11h 32m 43s
Lat.	49° 10′ 0″	Sec	.18451	G. S. T.	12h 32m 21s
P. D.	70° 29′ 30″	Csc	.02568		
	2)166° 6′ 5″			Long. T.	59m 38s
s	83° 3′ 2″	Cos	9.08276	Long.	14° 54′ 30″ W
s−h	36° 36′ 27″	Sin	9.77549		

Log. Hav. 9.06844 = H. A.

				R. A.	14h 12m 47s
h	46° 26′ 35″			H. A.	− 2h 37m 47s
Lat.	49° 50′ 0″	Sec	.19043		
P. D.	70° 29′ 30″	Csc	.01568	L. S. T.	11h 35m 0s
	2)166° 46′ 5″			G. S. T.	12h 32m 21s
s	83° 23′ 2″	Cos	9.06151		
s−h	36° 56′ 27″	Sin	9.77887	Long. T.	57m 21s
				Long.	14° 20′ 15″ W

Log. Hav. 9.05649 = H. A.

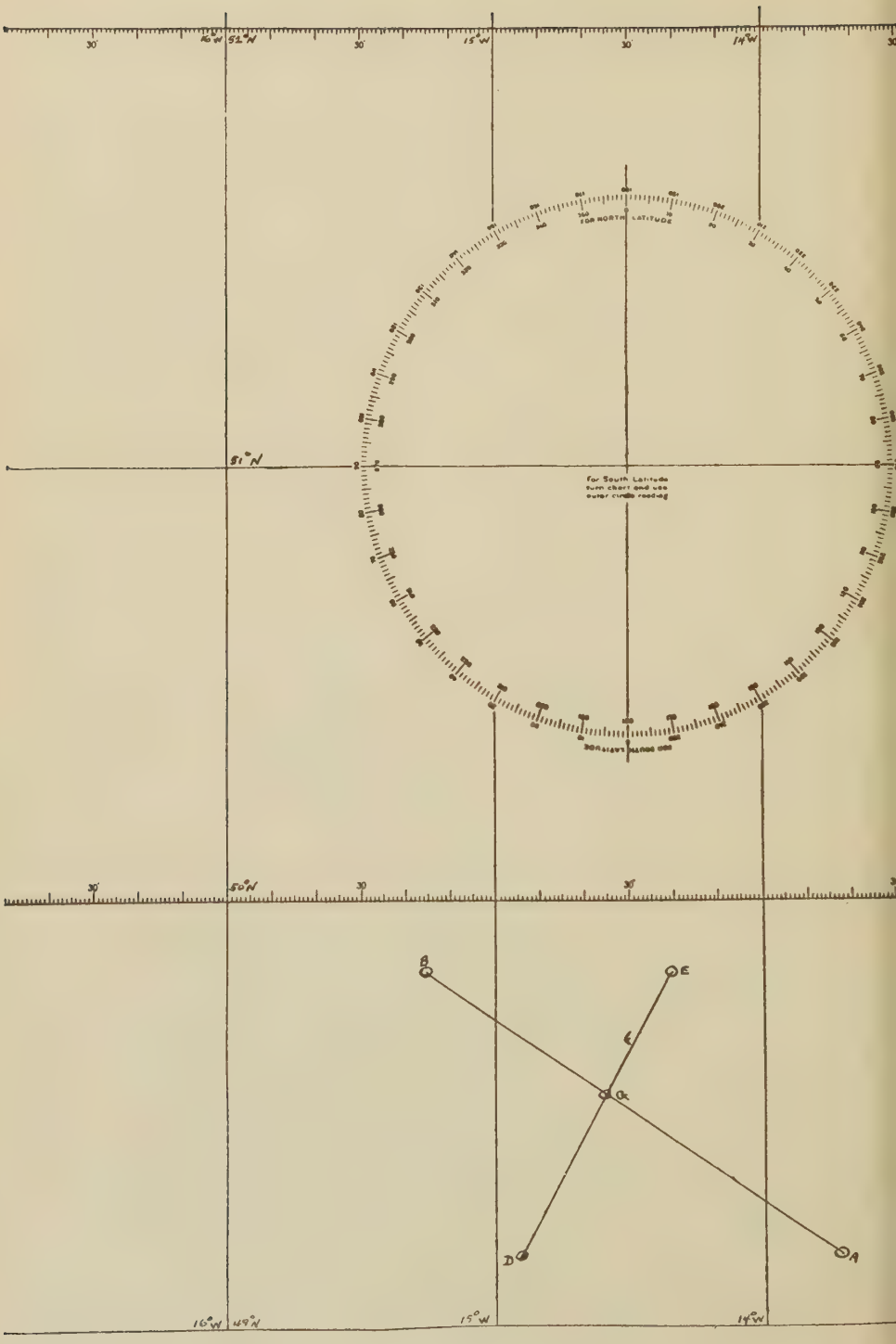
Second Observation

Lat. 49° 10′ N. Long. 14° 54′ 30″ W.
Lat. 49° 50′ N. Long. 14° 20′ 15″ W.

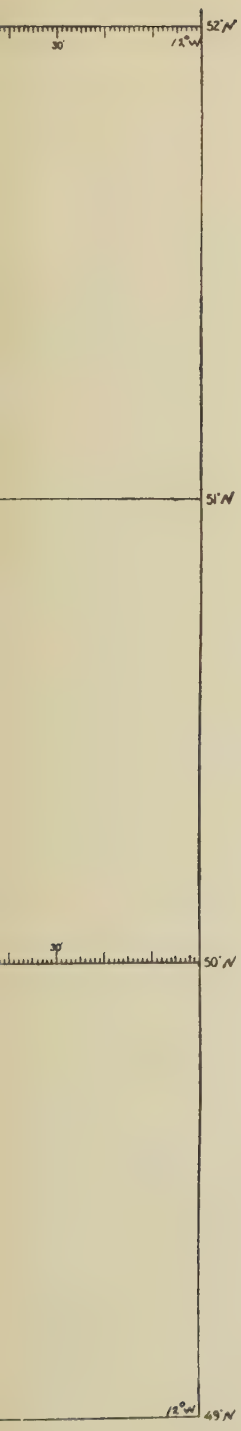
Place these two positions on chart and connect them with line. This will be Second Position Line.

Where the Second Position Line crosses the First Position Line will be the ship's position at observation.

See: Chartlet following this problem.
Sumner "Tangent" Method, Problem 2.
Marcq St. Hilaire Method, Problem 2.
Double Chronometer Method, Problem 2.



30'
16°W 52°N
30'
15°W
30'
14°W
FOR NORTH LATITUDE
51°N
For South Latitude turn chart and use outer circle reading
FOR SOUTH LATITUDE
30'
50°N
30
30'
B
E
G
D
A
16°W 49°N
15°W
14°W



Sumner's Method With Two Assumed Latitudes

Problem No. 2

A. 1st Observation Lat. 49° 10′ N Long. 13° 42′ 45″ W.

B. 1st Observation Lat. 49° 50′ N Long. 15° 15′ 15″ W.

C. 1st Position line. At right angles to true bearing.

D. 2d Observation Lat. 49° 10′ N Long. 14° 54′ 30″ W.

E. 2d Observation Lat. 49° 50′ N Long. 14° 20′ 15″ W.

F. 2d Position line. At right angles to true bearing.

G. Position of vessel Lat. 49° 33′ N Long. 14° 35′ 0″ W.

CHAPTER XL

SUMNER "TANGENT" METHOD

This is a very simple method of determining ship's position by Sumner Line. In the original Sumner Method two Latitudes were assumed and a sight for Longitude was worked by each of them. A line connecting the two positions found was the Line of Position, and the ship's position was somewhere on this line. By the Tangent Method it is only necessary to work one sight for Longitude with the Latitude of D. R. After plotting this position on the chart, a line drawn at right angles to Body's True Bearing (which is obtained from Azimuth Table) will be the Line of Position. If the observation made, and calculations for same are correct, the ship's position will be somewhere on this line.

In using the sun another observation worked in the same manner, after the sun has changed its bearing two or more points, will give another position line. Where this line crosses the first line, after the first line is brought forward for course and distance run in interval, will be the ship's position at second observation.

RULE:

1. Take observation and determine Longitude by same, using D. R. Lat.
2. Take out Body's True Bearing from Azimuth Table.
3. Plot position found on Chart.
4. Draw a line through position at right angles to Body's True Bearing. (90° from it.) This will be First Line of Position.
5. If there is an interval between First and Second Observations, allow for course and distance run in interval, and draw a line parallel to First Line of position. This will be First Line of position projected for course and distance.
6. Take another observation after body has changed its bearing two or more points, and plot second line as

before. In working this observation it is necessary to use the Lat. D. R. brought forward from First Observation.

7. Where the second line crosses the projection of first line will be the ship's position at Second Observation.
8. If the observations were simultaneous use the same D. R. Lat. for each observation. After determining Long. of same, plot the position lines as before. Where they cross one another will be ship's position.

PROBLEM NO. 1

March 4, 1936. 7.30 A. M. at ship. Obs. Alt. Sun's L. L. 13° 21′ 45″. Dip 36 ft. Chron. read 12h 15m 25s P. M., which was slow 2m 8s. Lat. D. R. 37° 25′ N.

At 10 A. M. Obs. Alt. Sun's L. L. 37° 23′. Chron. read 2h 45m P. M. Ship ran between observations S 84° W (true) 12 knots per hour. Required position at Second Observation?

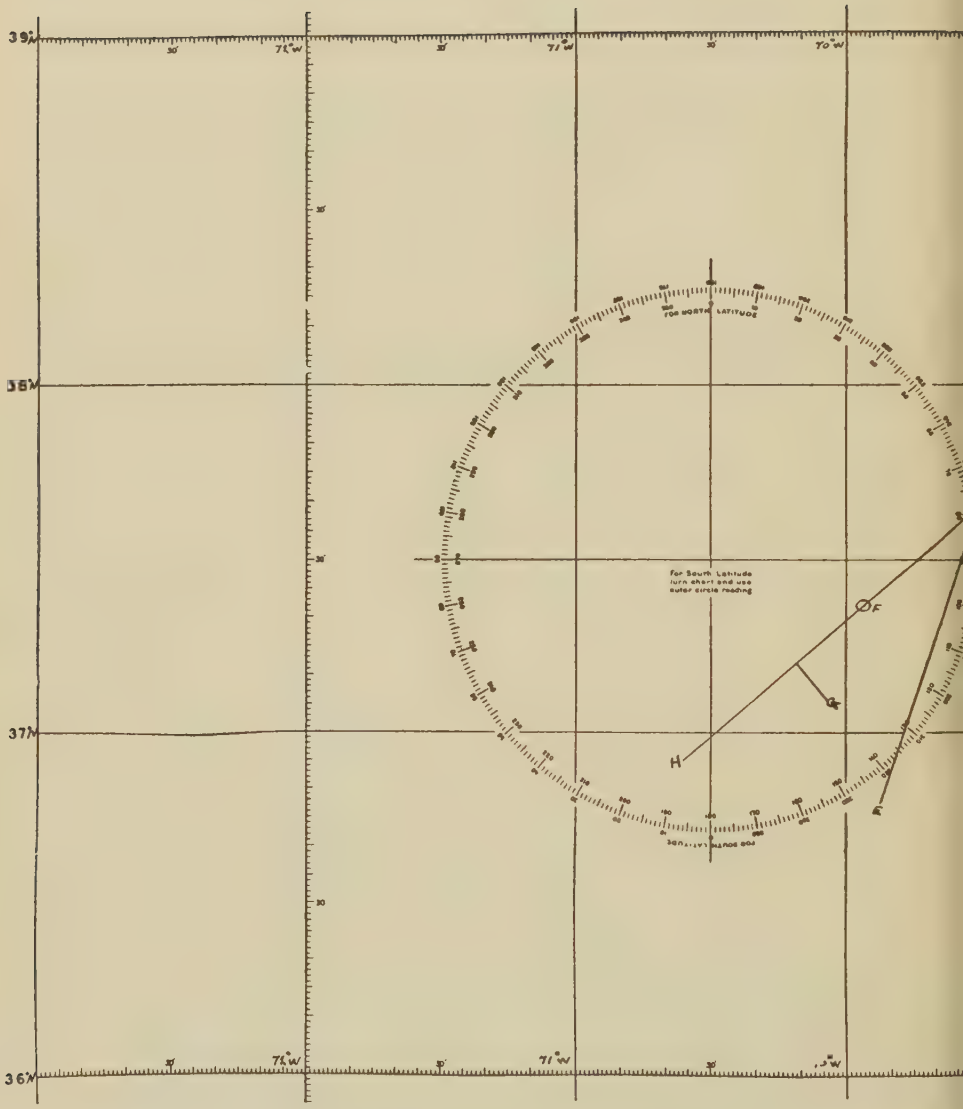
First Observation

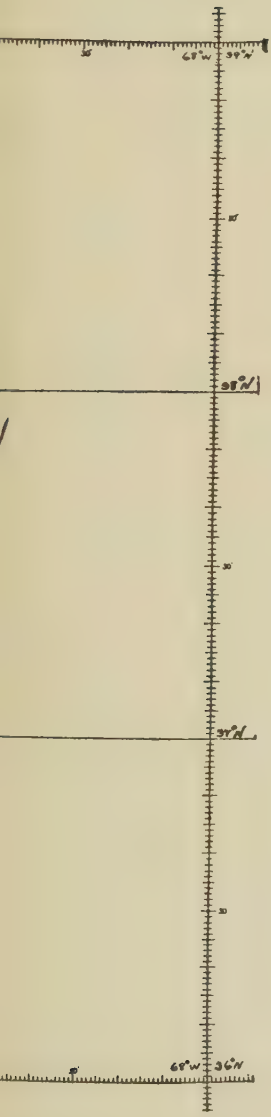
Chron.	12h 15m 25s		Dec. 4d 12h	6° 23′.4
Slow	+ 2m 8s		Corr. for .3h	− .3
G. C. T. 4d	12h 17m 33s		Dec. 4d 12.3h	6° 23′.1 S
Eq. Time	− 12m 5s			+90° 0′.0
G. A. T. 4d	12h 5m 28s		P. D.	96° 23′.1
Obs. Alt.	13° 21′ 45″			
Corr. (46)	+ 6′ 23″			
h	13° 28′ 8″			
Lat. D. R.	37° 25′ 0″	Sec	.10005	
P. D.	96° 23′ 6″	Csc	.00270	
	2)147° 16′ 14″			
s	73° 38′ 7″	Cos	9.44987	
s−h	60° 9′ 59″	Sin	9.93826	

Log. Hav. 9.49088 = L. A. T. 4d 7h 29m 30s
G. A. T. 4d 12h 5m 28s

Long. T. 4h 35m 58s
Azimuth N 109° E Long. 68° 59′ 30″ W

Place this position on chart. Through position draw a line at right angles to sun's true bearing, or N 109° E − 90° = N 19° E. This will be the First Position Line.


39
38
37
36
For South Latitude turn chart and use outer circle reading
F
G
H



Sumner "Tangent" Method

Problem No. 1

A. 1st Observation Lat. 37° 25′ N Long. 68° 59′ 30″ W.

B. Sun's true bearing N 109° E.

C. 1st Position line. Through position at right angles to sun's true bearing, or N 109° E − 90° = N 19° E.

D. Course and distance run between observations S 84° W 30 miles.

E. 1st Position line, projected for course and distance.

F. 2d Observation. Lat. 37° 21′ 54″ N Long. 69° 56′ 0″ W.

G. Sun's true bearing N 140° E.

H. 2d Position line. Through position at right angles to true bearing, or N 140° E − 90° = N 50° E.

I. Position of vessel at 2d observation Lat. 37° 39′ 30″ N Long. 69° 29′ 15″ W.

From the First Position Line allow the course and distance run between First and Second Observations, and draw a line through this point parallel to First Position Line. This will be the First Position Line projected.

Bring the Lat. D. R. for First Observation forward to Second Observation.

Lat. D. R. 1st Obs. 37° 25′ 0″ N Course S 84° W Dist 30 = D. Lat. 3.1
D. Lat. 3′ 6″ S

Lat. D. R. 2d Obs. 37° 21′ 54″ N

Second Observation

Chron.	14h 45m 0s	Dec. 4d 14h	6° 21′.5
Slow	+ 2m 8s	Corr. for .8h	− .8
G. C. T. 4d	14h 47m 8s	Dec. 4d 14.8h	6° 20′.7 S
Eq. Time	− 11m 50s		+90° 0′.0
G. A. T. 4d	14h 35m 18s	P. D.	96° 20′.7

Obs. Alt.	37° 23′ 0″		
Corr. (46)	+ 9′ 7″		
h	37° 32′ 7″		
Lat. D. R.	37° 21′ 54″	Sec	.09975
P. D.	96° 20′ 42″	Csc	.00267
	2)171° 14′ 43″		
s	85° 37′ 21″	Cos	8.88268
s − h	48° 5′ 14″	Sin	9.87167

Log. Hav. 8.85677 = L. A. T. 4d 9h 55m 34s
G. A. T. 4d 14h 35m 18s
Long. T. 4h 39m 44s
Azimuth N 140° E Long. 69° 56′ 0″ W

Place this position on chart. Through this position draw a line at right angles to sun's true bearing, or N 140° E − 90° = N 50° E. This will be the Second Position Line.

Where the Second Position Line crosses the projection of the First Position Line will be the position of vessel at Second Observation.

See: Chartlet facing page.
Sumner's Method with two assumed latitudes, Problem 1.
Marcq St. Hilaire Method, Problem 1.
Double Chronometer Method, Problem 1.

PROBLEM NO. 2

SIMULTANEOUS OBSERVATIONS OF TWO FIXED STARS

Dec. 6, 1936. A. M. at ship. D. R. Lat. 49° 30′ N. Obs. Alt. *Regulus bearing W 48° 41′. Chron. read 7h 17m 15s, which was slow 14m 6s. Immediately afterwards Obs. Alt. *Arcturus bearing E 46° 32′ 30″. Chron. read 7h 18m 37s. Dip 26 ft. Required position of vessel?

First Observation, Regulus W

Chron.	7h 17m 15s		Dec.		12° 16′.5 N
Slow	+ 14m 6s				−90° 0′.0
G. C. T. 6d	7h 31m 21s		P. D.		77° 43′.5
S. T. 0h G. T.	4h 58m 24s				
Corr.	1m 14s				
G. S. T.	12h 30m 59s				

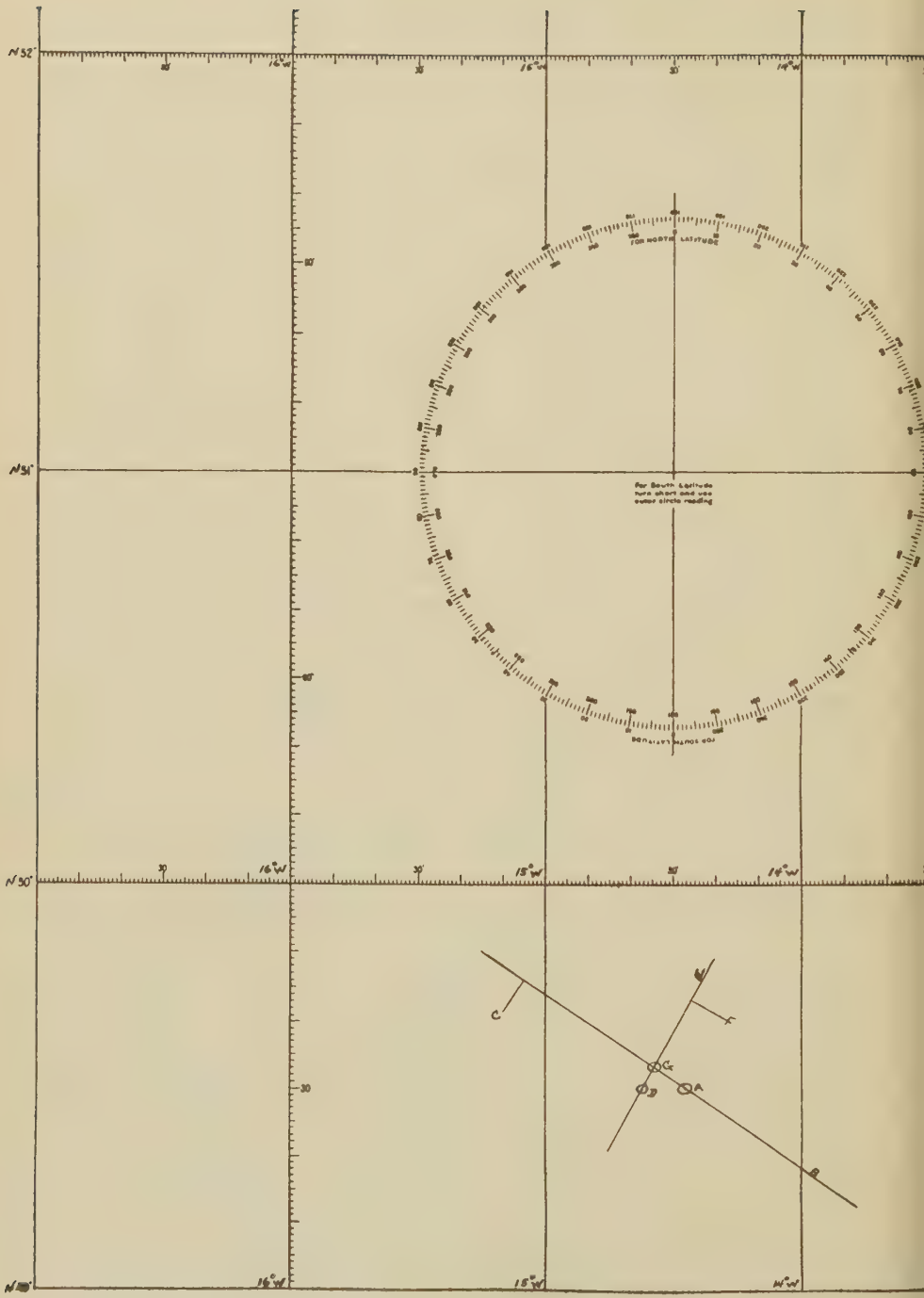
Obs. Alt.	48° 41′ 0″			R. A.	10h 5m 2s
Corr. (46)	− 5′ 51″			H. A.	+ 1h 28m 7s
h	48° 35′ 9″			L. S. T.	11h 33m 9s
Lat.	49° 30′ 0″	Sec	.18746	G. S. T.	12h 30m 59s
P. D.	77° 43′ 30″	Csc	.01005		
	2)175° 48′ 39″			Long. T.	57m 50s
s	87° 54′ 19″	Cos	8.56290	Long.	14° 27′ 30″ W
s − h	39° 19′ 10″	Sin	9.80185		

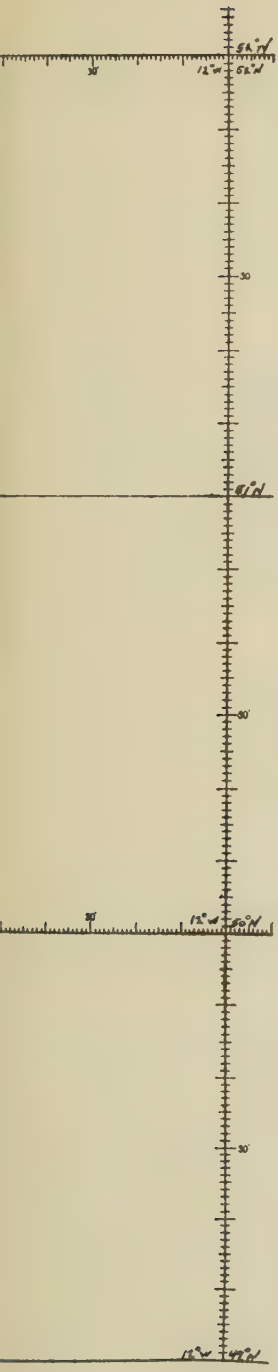
Log. Hav. 8.56226 = H. A. Az. N 146° W

Place this position on chart. Through position draw a line at right angles to star's true bearing, or N 146° W − 90° = N 56° W. This will be the First Position Line.

Second Observation, Arcturus E

Chron.	7h 18m 37s	Dec.	19° 30′.5 N
Slow	+ 14m 6s		−90° 0′.0
G. C. T. 6d	7h 32m 43s	P. D.	70° 29′.5
S. T. 0h G. T.	4h 58m 24s		
Corr.	1m 14s		
G. S. T.	12h 32m 21s		


N 52°
N 51°
N 50°
16°W
15°W
14°W
FOR NORTH LATITUDE
For South Latitude turn chart and use outer circle reading
FOR SOUTH LATITUDE
C
G
D
A
B



Sumner "Tangent" Method

Problem No. 2

A. 1st Position * Regulus Lat. 49° 30′ N Long. 14° 27′ 30″ W.

B. 1st Position line, at right angles to true bearing, or N 146° W − 90° = N 56° W.

C. True bearing of Regulus N 146° W.

D. 2d Position * Arcturus Lat. 49° 30′ N Long. 14° 37′ 45″ W.

E. 2d Position line, at right angles to true bearing, or N 119° E − 90° = N 29° E.

F. True bearing of Arcturus N 119° E.

G. Position of vessel Lat. 49° 33′ N Long. 14° 35′ 0″ W.

Obs. Alt.	46° 32′ 30″			R. A.	14h 12m 47s
Corr. (46)	− 5′ 55″			H. A.	− 2h 38m 57s
h	46° 26′ 35″			L. S. T.	11h 33m 50s
Lat.	49° 30′ 0″	Sec	.18746	G. S. T.	12h 32m 21s
P. D.	70° 29′ 30″	Csc	.02568		
	2)166° 26′ 5″			Long. T.	58m 31s
s	83° 13′ 2″	Cos	9.07227	Long.	14° 37′ 45″ W
s−h	36° 46′ 27″	Sin	9.77719		

Log. Hav. 9.06260 = H. A. Az. N. 119° E

Place this position on chart. Through position draw a line at right angles to star's true bearing, or N 119°E − 90° = N 29° E. This will be the Second Position Line, and where it crosses the First Position Line will be ship's position.

See: Chartlet facing p.
Sumner's Method with two assumed latitudes, Problem 2.
Marcq St. Hilaire Method, Problem 2.
Double Chronometer Method, Problem 2.

CHAPTER XLI

DOUBLE CHRONOMETER METHOD FOR DETERMINING POSITION BY TWO OBSERVATIONS

The position of the ship may be determined by this method both accurately and easily without the use of plotting charts or graphic methods. The results obtained will be the same as plotting Sumner lines. It is especially useful in cloudy weather when it is doubtful that the meridian altitude will be available on that day. It is applicable not only to sun observations, which are naturally preferred, but also to observations of two stars, or other celestial bodies.

RULE:

1. Take an observation of heavenly body, and determine longitude by same, using latitude by dead reckoning.
2. Take out azimuth of body observed.

   NOTE:—If azimuth exceeds 90°, subtract it from 180°, and name in adjacent quadrant.

3. Enter Table 47 (Bowditch) with latitude at top of page and azimuth at side, and take out the corresponding longitude factor (F).
4. *In case of an interval between observations:*
   After the body changes its bearing two or more points, take another observation.
5. Apply to the first position the difference of latitude and longitude to Second Observation, using the course and distance run in interval. This will be the First Observation brought forward to Second Observation.
6. Compute the longitude of Second Observation, using latitude brought forward.
7. Take out azimuth and longitude factor as before. This will be Factor II.

8. *In case of simultaneous observations:*
   Take observations of two heavenly bodies (preferably in adjacent quadrants), and compute the longitude of each, using the same D. R. latitude.
9. Take out the azimuths and longitude factor for each.
10. *In all cases:*
    If both observations were in the same or opposite quadrants, subtract the smallest from the greatest factor.
11. If the observations were in adjacent quadrants, add the two factors.
12. Find the difference of longitude, between the longitude of First Observation brought forward to Second Observation, and the longitude of Second Observation.
13. Divide the difference of longitude by the sum or difference of the two factors. The result will be the error in the latitude used.
14. Multiply Factor I by the latitude error. The result will be the correction for longitude of First Observation brought forward to Second Observation. Apply this correction by rule explained below.
15. Multiply Factor II by the latitude error. The result will be correction to longitude of Second Observation.
16. Apply the latitude error to the latitude used at Second Observation, by rule below, and the result will be the correct latitude at Second Observation.
17. If the observations and calculations are correct the two longitudes will agree, and consequently the position of the vessel will be correct.

HOW TO APPLY THE CORRECTIONS FOR LATITUDE AND LONGITUDE

If it is found that there is a difference of longitude between the longitude of First Observation brought forward to Second Observation and the longitude of Second Observation it is evident that there must be an error in the latitude used.

If the bodies observed are in the same or opposite quadrants the error in longitude caused by an error in latitude

is for both observations in the same direction—i.e., both east or both west.

To determine in which way to apply this correction we find the direction in which the error is increasing.

For example, in Problem 1 (which is in same quadrants) we find a difference of longitude between First Observation brought forward and Second Observation of 9′ 15″ further west. It is evident from this that there is an error in the latitude we are using, and it is increasing the error in longitude to the westward.

As the bodies are in the same quadrant, the corrections for both longitudes must be applied in the same direction, and as the error is increasing to the west, the corrections must be applied to the east.

The latitude correction in this case will be applied to the north, as in this instance the further south the latitude the further west it will make the longitude.

A simple method of how to find the direction for the latitude correction is as follows:

Put down the direction of the azimuth, and under it its opposite direction; a diagonal line from the direction of the longitude correction will give the direction of the latitude correction.

For example, in Problem 1:

Correction to longitude of Second Observation, to be applied to east.

Azimuth of body S / E
N / W (opposite)

As the correction to longitude is to east, a diagonal line from east points to north, which is the direction for the latitude correction.

If the bodies observed are in adjacent quadrants, the error in longitude produced by error in latitude is one east and one west.

Taking Problem 2 we find:

Long. First Obs. 14° 27′ 30″ W
Long. Sec. Obs. 14° 37′ 45″ W

Diff. Long. 10′ 15″ (Sec. Obs. west of First Obs.)

As the Second Observation is west of First Observation, the First will be corrected to the west, and the Second to the east.

To find the direction for the latitude correction, applying above rule:

Azimuth First Obs. S / W
N / E (opposite)

As the longitude correction is to west, the diagonal line shows latitude correction to be north.

Azimuth Second Obs. S / E
N / W (opposite)

As the longitude correction is to east, the diagonal line shows latitude correction to be north.

PROBLEM NO. 1

SUN IN SAME QUADRANT

March 4, 1936, at 7.30 A. M. Obs. Alt. Sun's L. L. 13° 21′ 45″. Dip 36 ft. Chron. read 12h 15m 25s P. M., which was slow 2m 8s. Lat. D. R. 37° 25′ N.

At 10 A. M. Obs. Alt. Sun's L. L. 37° 23′. Chron. read 2h 45m P. M.

Ship ran in interval S 84° W (true) 12 knots per hour.

Required position at Second Observation?

First Observation

Chron.	12h 15m 25s	Dec. 4d 12h	6° 23′.4	
Slow	+ 2m 8s	Corr. for .3h	− .3	
G. C. T. 4d	12h 17m 33s	Dec. 4d 12.3h	6° 23′.1	S
Eq. Time	− 12m 5s		+90° 0′.0	
G. A. T. 4d	12h 5m 28s	P. D.	96° 23′.1	
Obs. Alt.	13° 21′ 45″			
Corr. (46)	+ 6′ 23″			
h	13° 28′ 8″			
Lat. D. R.	37° 25′ 0″	Sec	.10005	
P. D.	96° 23′ 6″	Csc	.00270	
	2)147° 16′ 14″			
s	73° 38′ 7″	Cos	9.44987	
s−h	60° 9′ 59″	Sin	9.93826	

Log. Hav. 9.49088 = L. A. T. 4d 7h 29m 30s
G. A. T. 4d 12h 5m 28s

Azimuth N 109° E or S 71° E
Factor I .44

Long. T. 4h 35m 58s
Long. First Obs. 68° 59′ 30″ W

First Position Brought Forward to Second Observation

Course S 84° W. Dist. 30 = D. Lat. 3.1 S. D. Long. 37′ 30″ W.

Lat. First Obs.	37° 25′ 0″ N	Long. First Obs.	68° 59′ 30″ W
Diff. Lat.	3′ 6″ S	Diff. Long.	37′ 30″ W
Lat. brought forward	37° 21′ 54″ N	Long. brought forward	69° 37′ 0″ W

Second Observation

Chron.	14h 45m 0s	Dec. 4d 14h	6° 21′.5
Slow	+ 2m 8s	Corr. for .8h	− .8
G. C. T. 4d	14h 47m 8s	Dec. 4d 14.8h	6° 20′.7 S
Eq. Time	− 11m 50s		+90° 0′.0
G. A. T. 4d	14h 35m 18s	P. D.	96° 20′.7

Obs. Alt.	37° 23′ 0″		
Corr. (46)	+ 9′ 7″		
h	37° 32′ 7″		
Lat. D. R.	37° 21′ 54″	Sec	.09975
P. D.	96° 20′ 42″	Csc	.00267
	2)171° 14′ 43″		
s	85° 37′ 21″	Cos	8.88268
s − h	48° 5′ 14″	Sin	9.87167

Log. Hav. 8.85677 = L. A. T. 4d 9h 55m 34s
G. A. T. 4d 14h 35m 18s

Azimuth N 140° E or S 40° E — Long. T. 4h 39m 44s
Factor II 1.49 — Long. Sec. Obs. 69° 56′ 0″ W

Long. First Obs. brought forward	69° 37′ 0″ W	Factor I	.44
Long. Second Obs.	69° 56′ 0″ W	Factor II	1.49
Diff. Long.	19′ 0″ W	Diff.	1.05

Diff. Long. $\frac{19'.0}{1'.05}$ = Lat. Error 18′.1
Diff. Factors

Lat. Error 18′.1 × Factor I .44 = 7′.96 correction to Long. First Obs.

Long. First Obs. brought forward	69° 37′ 0″ W	Az.	S / E
Long. Corr.	7′ 58″ E		N / W
Correct Long. First Obs.	69° 29′ 2″ W		

Lat. Error 18′.1 × Factor II 1.49 = 26′.97 correction to Long. Second Obs.

Long. Second Obs.	69° 56′ 0″ W	Azimuth	S / E
Long. Corr.	26′ 58″ E		N / W
Corr. Long. Second Obs.	69° 29′ 2″ W		

As the longitude correction is east, a diagonal line from east makes latitude correction north.

Lat. Second Obs.	37° 21′ 54″ N	Position of vessel:	
Lat. Error	18′ 6″ N	Lat.	37° 40′ 0″ N
		Long.	69° 29′ 2″ W
Corr. Lat.	37° 40′ 0″ N		

See: Sumner's Method with two assumed latitudes, Problem 1.
Sumner's "Tangent" Method, Problem 1.
Marcq St. Hilaire Method, Problem 1.
H. O. 208 and 211 Method, Problem 1.

PROBLEM NO. 2

SIMULTANEOUS OBSERVATIONS OF TWO FIXED STARS IN ADJACENT QUADRANTS

Dec. 6, 1936. A. M. at ship. D. R. Lat. 49° 30′ N. Obs. Alt. *Regulus bearing W 48° 41′. Chron. read 7h 17m 15s, which was slow 14m 6s. Immediately afterwards Obs. Alt. *Arcturus bearing E 46° 32′ 30″. Chron. read 7h 18m 37s. Dip 26 ft. Required position of vessel?

First Observation, Regulus W

Chron.	7h 17m 15s	Dec.	12° 16′.5 N
Slow	+ 14m 6s		−90° 0′.0
G. C. T. 6d	7h 31m 21s	P. D.	77° 43′.5
S. T. 0h G. T.	4h 58m 24s		
Corr.	1m 14s		
G. S. T.	12h 30m 59s		

Obs. Alt.	48° 41′ 0″				
Corr. (46)	− 5′ 51″			R. A.	10h 5m 2s
h	48° 35′ 9″			H. A.	+ 1h 28m 7s
Lat. D. R.	49° 30′ 0″	Sec	.18746		
P. D.	77° 43′ 30″	Csc	.01005	L. S. T.	11h 33m 9s
	2)175° 48′ 39″			G. S. T.	12h 30m 59s
s	87° 54′ 19″	Cos	8.56290		
s−h	39° 19′ 10″	Sin	9.80185	Long. T.	57m 50s
				Long. 1st Obs.	14° 27′ 30″ W

Log. Hav. 8.56226 = H. A.

Azimuth S 34° W
Factor I 2.29

Second Observation, Arcturus E

Chron.	7h 18m 37s		Dec.		19° 30′.5 N
Slow	+ 14m 6s				−90° 0′.0
G. C. T. 6d	7h 32m 43s		P. D.		70° 29′.5
S. T. 0h G. T.	4h 58m 24s				
Corr.	1m 14s				
G. S. T.	12h 32m 21s				
Obs. Alt.	46° 32′ 30″				
Corr. (46)	− 5′ 55″			R. A.	14h 12m 47s
				H. A.	− 2h 38m 57s
h	46° 26′ 35″				
Lat. D. R.	49° 30′ 0″	Sec	.18746	L. S. T.	11h 33m 50s
P. D.	70° 29′ 30″	Csc	.02568	G. S. T.	12h 32m 21s
	2)166° 26′ 5″				
s	83° 13′ 2″	Cos	9.07727	Long. T.	58m 31s
s − h	36° 46′ 27″	Sin	9.77719	Long. Sec. Obs.	14° 37′ 45″ W
		Log. Hav.	9.06260 = H. A.		

Azimuth S 61° E
Factor II .85

Long. First Obs.	14° 27′ 30″ W	Factor I	2.29
Long. Second Obs.	14° 37′ 45″ W	Factor II	.85
Diff. Long.	10′ 15″ W	Sum	3.14

Diff. Long. $\frac{10'.25}{3'.14}$ = 3′.27 Lat. Error
Sum Factors

Lat. Error 3′.27 × Factor I 2′.29 = 7′.49 correction to Long. First Obs.

Long. First Obs.	14° 27′ 30″ W	Azimuth S ⁄ W, N ⁄ E
Long. Corr.	7′ 30″ W	Lat. correction N
Corr. Long. First Obs.	14° 35′ 0″ W	

Lat. Error 3′.27 × Factor II .85 = 2′.78 correction to Long. Second Obs.

Long. Second Obs.	14° 37′ 45″ W	Azimuth S ⁄ E, N ⁄ W
Long. Corr.	2′ 45″ E	Lat. correction N
Corr. Long. Second Obs.	14° 35′ 0″ W	
Lat. D. R.	49° 30′ 0″ N	Position of Vessel:
Lat. Error	3′ 27″ N	Lat. 49° 33′ 27″ N
Corr. Lat.	49° 33′ 27″ N	Long. 14° 35′ 0″ W

See: Sumner's Method with two assumed latitudes, Problem 2.
Sumner's "Tangent" Method, Problem 2.
Marcq St. Hilaire Method, Problem 2.

PROBLEM NO. 3

STAR AND SUN IN ADJACENT QUADRANTS

Jan. 9, 1936. At 6.20 A. M. Obs. Alt. *Vega bearing E 24° 33′ 20″. Dip 40 ft. Chron. read 12h 33m 8s P. M., which was fast 34m 55s. Lat. D. R. 23° 50′ 30″ N.

Same date at 8.05 A. M. Obs. Alt. Sun's L. L. 13° 21′ 37″. Chron. read 2h 16m 8s P. M., fast 34m 56s.

Ship ran in interval between observations 241° (true) 18 miles.

Required position at Second Observation?

First Observation, Vega E

Chron.	12h 33m 8s		Dec.		38° 43′.4 N
Fast	− 34m 55s				−90° 0′.0
G. C. T. 9d	11h 58m 13s		P. D.		51° 16′.6
S. T. 0h G. T.	7h 9m 27s				
Corr.	1m 58s				
G. S. T.	19h 9m 38s				
Obs. Alt.	24° 33′ 20″			R. A.	18h 34m 45s
Corr. (46)	− 8′ 20″			H. A.	− 5h 8m 0s
h	24° 25′ 0″			L. S. T.	13h 26m 45s
Lat. D. R.	23° 50′ 30″	Sec	.03874	G. S. T.	19h 9m 38s
P. D.	51° 16′ 36″	Csc	.10781		
	2)99° 32′ 6″			Long. T.	5h 42m 53s
s	49° 46′ 3″	Cos	9.81016	Long. First Obs.	85° 43′
s − h	25° 21′ 3″	Sin	9.63160	15″ W	

Log. Hav. 9.58831 = H. A.

Azimuth N 56° E

Factor I .74

First Position Brought Forward to Second Observation

True course 241°. Dist. 18 = D. Lat. 8.7S. D. Long. 17′ 15″ W.

Lat. D. R. First Obs.	23° 50′ 30″ N	Long. First Obs.	85° 43′ 15″ W
Diff. Lat.	8′ 42″ S	Diff. Long.	17′ 15″ W
Lat. brought forward	23° 41′ 48″ N	Long. brought forward	86° 0′ 30″ W

Second Observation, Sun

Chron.	14h 16m 8s	Dec. 9d 12h	22° 13′.7
Fast	− 34m 56s	Corr. for 1.7h	− .5
G. C. T. 9d	13h 41m 12s	Dec. 9d 13.7h	22° 13′.2 S
Eq. Time	− 6m 54s		+90° 0′.0
G. A. T. 9d	13h 34m 18s	P. D.	112° 13′.2

Obs. Alt.	13° 21′ 37″			
Corr. (46)	+ 6′ 14″			
h	13° 27′ 51″			
Lat.	23° 41′ 48″	Sec	.03825	L. A. T. 9d 7h 47m 59s
P. D.	112° 13′ 12″	Csc	.03351	G. A. T. 9d 13h 34m 18s
	2)149° 22′ 51″			
s	74° 41′ 25″	Cos	9.42167	Long. T. 5h 46m 19s
s−h	61° 13′ 34″	Sin	9.94277	Long. Second Obs. 86° 34′ 45″ W
			Log. Hav. 9.43620	

Azimuth S 58° E
Factor 11 .68

Long. First Obs. forwarded	86° 0′ 30″ W	Factor I	.74
Long. Second Obs.	86° 34′ 45″ W	Factor II	.68
Diff. Long.	34′ 15″ W	Sum	1.42

Diff. Long. $\frac{34'.25}{1'.42}$ = 24′.12 Lat. Error
Sum Factors

Lat. Error 24′.12 × Factor I .74 = 17′.85 correction to Long. First Obs.

Long. First Obs. forwarded	86° 0′ 30″ W	Azimuth N ↖ E / S ↙ W
Long. Corr.	17′ 51″ W	Lat. correction N
Corr. Long. First Obs.	86° 18′ 21″ W	

Lat. Error 24′.12 × Factor II .68 = 16′.4 correction to Long. Second Obs.

Long. Second Obs.	86° 34′ 45″ W	Azimuth S ↗ E / N ↙ W
Long. Corr.	16′ 24″ E	Lat. correction N
Corr. Long. Second Obs.	86° 18′ 21″ W	
Lat. Second Obs.	23° 41′ 48″ N	Position of vessel:
Lat. Error	24′ 7″ N	Lat. 24° 5′ 55″ N
Corr. Lat.	24° 5′ 55″ N	Long. 86° 18′ 21″ W

See: Marcq St. Hilaire Method, Problem 3.

CHAPTER XLII

MARCQ ST. HILAIRE METHOD (COSINE—HAVERSINE FORMULA)

This method of plotting position lines is now being used extensively in the merchant service and the navy.

There are three formulas which may be used—namely the cosine-haversine formula, the haversine formula, and the sine-cosine formula. As the rules in the cosine-haversine formula never vary, it is the one most generally used, and all the problems herein are worked by that formula.

The position of the ship by dead reckoning must always be used to work from, and in the case where a course and distance are given in the interval between observations, the position by dead reckoning must be found for Second Observation before working problem.

RULE:

In case of the Sun observed:

1. Apply to G. C. T. the Equation of Time and find G. A. T.
2. Apply the D. R. Long. in time to G. A. T. and find L. A. T. or Hour Angle (H. A.).

In case of moon, star or planet observed:

1. Find the Greenwich Siderial Time (G. S. T.).
2. Apply to the G. S. T. the D. R. Long. in time, any find Local Siderial Time (L. S. T.).
3. From L. S. T. subtract Right Ascension of body observed. Result will be Hour Angle.

In all cases:

1. Take out the true declination of body observed.
2. Find the true altitude.
3. Take out the following logs.:
   Log. haversine of hour angle.
   Log. cosine of true declination.
   Log. cosine of D. R. latitude.

Add these three logs. and subtract 20 from index number.

4. Opposite log. haversine corresponding to sum of logs., read the natural haversine.
5. If latitude and declination are same name, subtract less from greater.
   If contrary names, add.
6. Take out natural haversine of sum or difference, and add to it the natural haversine obtained before.
7. Natural haversine corresponding to this sum will be the zenith distance (Z. D.).
8. Subtract Z. D. from 90°.
   Result will be computed altitude.
9. Take out true bearing of body from azimuth table.
10. Find the difference between computed altitude and true altitude.
    Result will be altitude difference or intercept.
11. With the true azimuth as a course, and the altitude difference as the distance, enter Table 2 and find the difference of latitude and longitude.
12. Apply the Diff. Lat. and Long. to the D. R. position as follows:
    If the true altitude is greater than the computed altitude, the Diff. Lat. and Long. will have the same name as the azimuth.
    If the true altitude is less than the computed altitude, the Diff. Lat. and Long. will have the opposite name to the azimuth.
    In using the signs, + means toward the body, or same name as azimuth; −means away from body, or opposite name to azimuth.
13. The position obtained, after applying the Diff. Lat. and Long. to D. R. position will be the position on the Sumner line. Place this position on a chart or plotting sheet, and through it draw a line at right angles, or 90°, from true azimuth. This will be the line of position.
14. The same rules now apply to this method, as in Sumner's Method—i. e., where the two position lines cross, will be the ship's position.
    See chart following this problem for illustration.

PROBLEM NO. 1

TWO OBSERVATIONS OF THE SUN

March 4, 1936. At 7.30 A. M. Obs. Alt. Sun's L. L. 13° 21′ 45″. Dip 36 ft. Chron. read 12h 15m 25s P. M., which was slow 2m 8s. D. R. position 37° 25′ N, 68° 30′ W.

At 10 A. M. Obs. Alt. Sun's L. L. 37° 23′. Chron. read 2h 45m P. M. Ship ran in interval S 84° W (true) 12 knots per hour.

Required position at Second Observation?

First Observation

Chron.	12h 15m 25s	Dec. 4d 12h	6° 23′.4
Slow	+ 2m 8s	Corr. for .3h	− .3
G. C. T. 4d	12h 17m 33s	Dec. 4d 12.3h	6° 23′.1 S
Eq. Time	− 12m 5s	Lat. D. R.	37° 25′.0 N
G. A. T. 4d	12h 5m 28s	Sum	43° 48′.1
Long.	− 4h 34m 0s		
H. A.	7h 31m 28s A. M.	Obs. Alt.	13° 21′ 45″
		Corr. (46)	+ 6′ 23″
		True Alt.	13° 28′ 8″

Log. Hav. H. A. 7h 31m 28s = 9.48530
Log. Cos. Lat. 37° 25′ = 9.89995
Log. Cos. Dec. 6° 23′ 6″ = 9.99730

Log. Hav. 9.38250 = Nat. Hav. .24127
Sum (Lat. Dec.) 43° 48′ 6″ Nat. Hav. .13913

Nat. Hav. .38040 = Z. D.

Z. D.	76° 9′ 30″	
	90° 0′ 0″	
Comp. Alt.	13° 50′ 30″	Azimuth N 109° E or S 71° E
True Alt.	13° 28′ 8″	
Alt. Diff.	− 22′ 22″	

TO COMPUTE POSITION ON FIRST SUMNER LINE

Since the true altitude is less than computed altitude, the position is farther removed from the observed body than the dead reckoning position, consequently, the altitude difference should be laid off opposite to azimuth, or N 71° W 22.4 miles from D. R. position.

Table 2 at N 71° W 22.4 = D. Lat. 7.3 N. Dep. 21.2 D. Long. 26′.5 W.

D. R. Lat.	37° 25′ 0″ N	D. R. Long.	68° 30′ 0″ W
D. Lat.	7′ 18″ N	D. Long.	26′ 30″ W
Comp. Pos. on S. Line	37° 32′ 18″ N		68° 56′ 30″ W

Place this position on chart, and through it draw a line at right angles to azimuth, or N 109° E − 90° = N 19° E. This will be the First Position Line.

As there has been an interval between First and Second Observation, it is necessary to carry the First Position Line forward to Second Observation, by allowing for the course and distance run between observations.

COMPUTED POSITION ON FIRST SUMNER LINE PROJECTED FOR COURSE AND DISTANCE RUN BETWEEN OBSERVATIONS

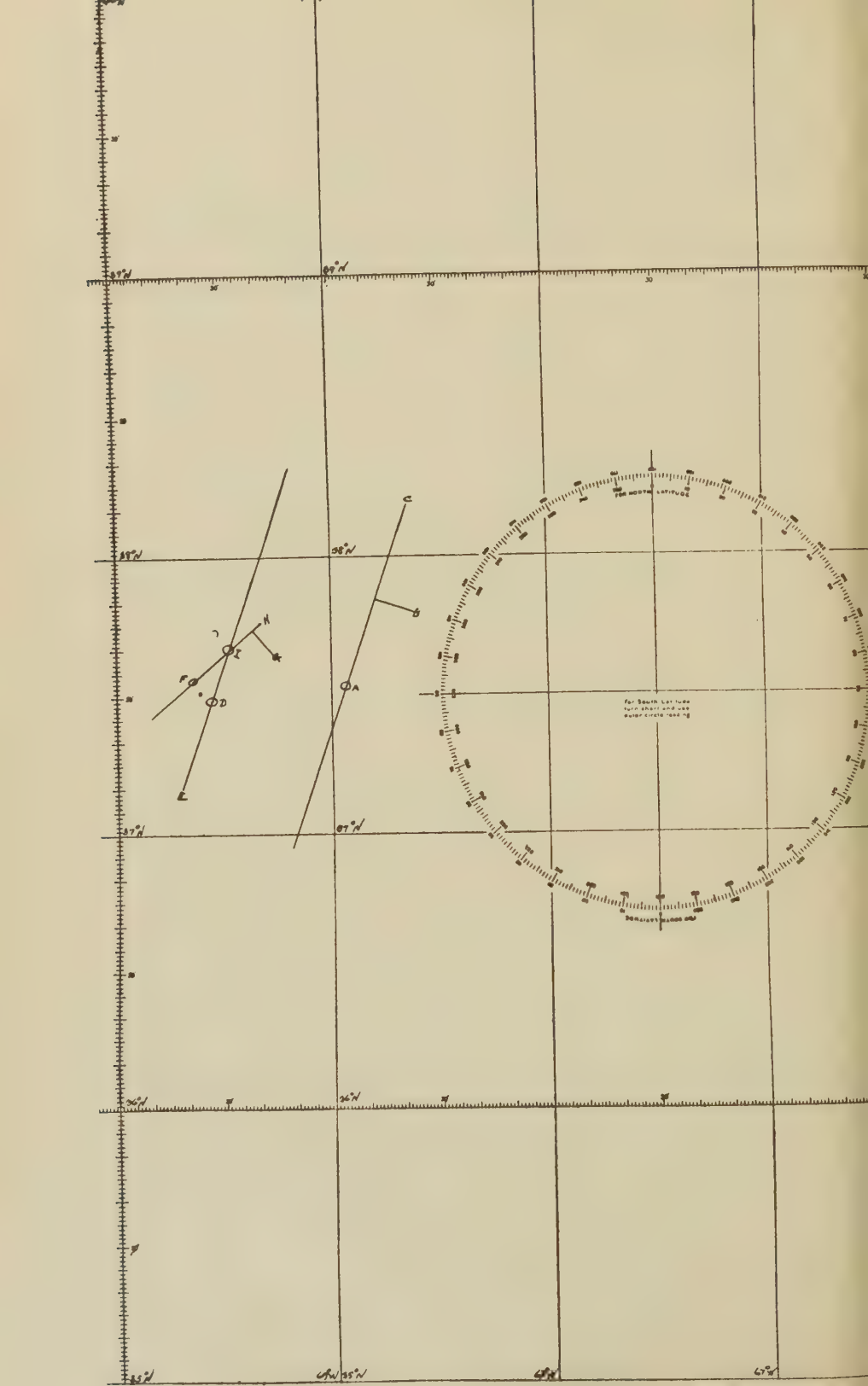
Course between observations S 84° W distance run 30 miles.

Table 2 at 84° Dist. 30 = D. Lat. 3.1 S. Dep. 29.8. D. Long. 37′ 45″ W.

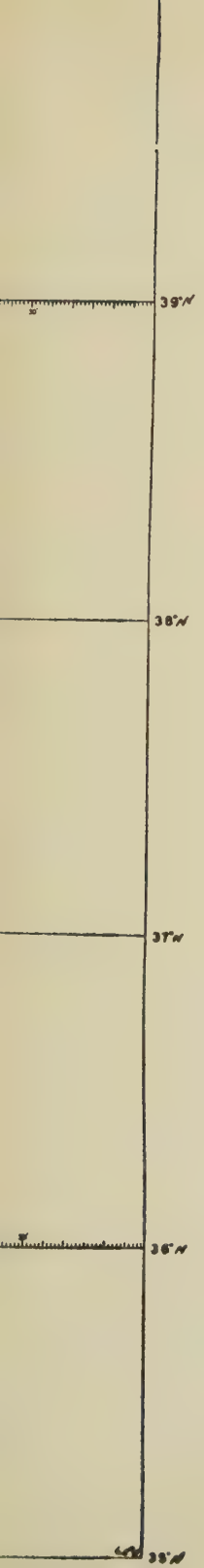
Comp. Pos. on 1st Sumner Line	37° 32′ 18″ N	68° 56′ 30″ W
D. Lat. and Long.	3′ 6″ S	37′ 45″ W
Comp. Pos. on 1st Sumner Line projected for course and dist.	37° 29′ 12″ N	69° 34′ 15″ W

Place this position on chart, and through it draw a line at right angles to true azimuth, or N 109° E − 90° = N 19° E. This line will be parallel to First Position Line, and will be called the First Position Line projected.

The above position will also be used as D. R. position for Second Observation.



FOR NORTH LATITUDE
For South Latitude turn short and use outer circle reading
DOMINATE MARGIN
A
B
C
D
E
F
G
H
I



Marcq St. Hilaire Method
Problem No. 1

A. Computed position on 1st Sumner line Lat. 37° 32′ 18″ N Long. 68° 56′ 30″ W.

B. Sun's true bearing N 109° E.

C. 1st Position line. Through computed position at right angles to true bearing, or N 109° E − 90° = N 19° E.

D. Computed position on 1st Sumner line projected for course and distance run between observations.

E. 1st Position line projected for course and distance. Through computed position at right angles to true bearing, or N 19° E.

F. Computed position on 2d Sumner line Lat. 37° 33′ 24″ N Long. 69° 38′ 45″ W.

G. Sun's true bearing N 140° E.

H. 2d Position line. Through computed position at right angles to true bearing, or N 140° E − 90° = N 50° E.

I. Position of vessel at 2d observation Lat. 37° 39′ 30″ N Long. 69° 29′ W.

Second Observation

D. R. position. Lat. 37° 29′ 12″ N. Long. 69° 34′ 15″ W.

Chron.	14h 45m 0s		Dec. 4d 14h	6° 21′.5	
Slow	+ 2m 8s		Corr. for .8h	− .8	
G. C. T. 4d	14h 47m 8s		Dec. 4d 14.8h	6° 20′.7	S
Eq. Time	− 11m 50s		Lat. D. R.	37° 29′.2	N
G. A. T. 4d	14h 35m 18s		Sum	43° 49′.9	
Long.	− 4h 38m 17s				
			Obs. Alt.	37° 23′ 0″	
H. A.	9h 57m 1s	A. M.	Corr. (46)	+ 9′ 7″	
			True Alt.	37° 32′ 7″	

Log. Hav. H. A. 9h 57m 1s = 8.84682
Log. Cos. Lat. 37° 29′ 12″ = 9.89954
Log. Cos. Dec. 6° 20′ 42″ = 9.99733

Log. Hav. 8.74369 = Nat. Hav. .05542
Sum (Lat. Dec.) 43° 49′ 54″ = Nat. Hav. .13931

Nat. Hav. .19473 = Z. D.

Z. D.	52° 22′ 15″	
	90° 0′ 0″	
Comp. Alt.	37° 37′ 45″	Azimuth N 140° E or S 40° E
True Alt.	37° 32′ 7″	
Alt. Diff.	− 5′ 38″	

TO COMPUTE POSITION ON SECOND SUMNER LINE

Using same rule as before, altitude difference should be laid off opposite to azimuth, or N 40° W 5.6 miles.

Table 2 at 40° Dist. 5.6 = D. Lat. 4.2 N. Dep. 3.6. D. Long. 4′ 30″ W.

2d D. R. Pos. Lat.	37° 29′ 12″ N	Long. 69° 34′ 15″ W
D. Lat. and Long.	4′ 12″ N	4′ 30″ W
Comp. Pos. on 2d Sumner Line	37° 33′ 24″ N	69° 38′ 45″ W

Place this position on chart, and through it draw a line at right angles to azimuth, or N 140° E − 90° = N 50° E. This will be the Second Position Line, and where it crosses

Second Observation

D. R. position. Lat. 37° 29′ 12″ N. Long. 69° 34′ 15″ W.

Chron.		14h 45m 0s	Dec. 4d 14h		6° 21′.5
Slow	+	2m 8s	Corr. for .8h	−	.8
G. C. T. 4d		14h 47m 8s	Dec. 4d 14.8h		6° 20′.7 S
Eq. Time	−	11m 50s	Lat. D. R.		37° 29′.2 N
G. A. T. 4d		14h 35m 18s	Sum		43° 49′.9
Long.	−	4h 38m 17s			
H. A.		9h 57m 1s A. M.	Obs. Alt.		37° 23′ 0″
			Corr. (46)	+	9′ 7″
			True Alt.		37° 32′ 7″

Log. Hav. H. A. 9h 57m 1s = 8.84682
Log. Cos. Lat. 37° 29′ 12″ = 9.89954
Log. Cos. Dec. 6° 20′ 42″ = 9.99733

Log. Hav. 8.74369 = Nat. Hav. .05542
Sum (Lat. Dec.) 43° 49′ 54″ = Nat. Hav. .13931

Nat. Hav. .19473 = Z. D.

Z. D.	52° 22′ 15″	
	90° 0′ 0″	
Comp. Alt.	37° 37′ 45″	Azimuth N 140° E or S 40° E
True Alt.	37° 32′ 7″	
Alt. Diff.	− 5′ 38″	

TO COMPUTE POSITION ON SECOND SUMNER LINE

Using same rule as before, altitude difference should be laid off opposite to azimuth, or N 40° W 5.6 miles.

Table 2 at 40° Dist. 5.6 = D. Lat. 4.2 N. Dep. 3.6. D. Long. 4′ 30″ W.

2d D. R. Pos. Lat.	37° 29′ 12″ N	Long. 69° 34′ 15″ W
D. Lat. and Long.	4′ 12″ N	4′ 30″ W
Comp. Pos. on 2d Sumner Line	37° 33′ 24″ N	69° 38′ 45″ W

Place this position on chart, and through it draw a line at right angles to azimuth, or N 140° E − 90° = N 50° E. This will be the Second Position Line, and where it crosses

the First Position Line projected will be the ship's position at Second Observation.

See: Chart following this problem.
Sumner's Method with two assumed latitudes, Problem 1.
Sumner's "Tangent" Method, Problem 1.
Double Chronometer Method, Problem 1.

PROBLEM NO. 2

SIMULTANEOUS OBSERVATIONS OF TWO FIXED STARS

Dec. 6, 1936. A. M. at ship. D. R. position 49° 30′ N, 14° W. Obs. Alt. *Regulus bearing W. 48° 41′. Dip 26 ft. Chron. read 7h 17m 15s, which was slow 14m 6s.

Immediately after Obs. Alt. *Arcturus bearing E 46° 32′ 30″. Chron. read 7h 18m 37s.

Required position of vessel?

First Observation, Regulus W

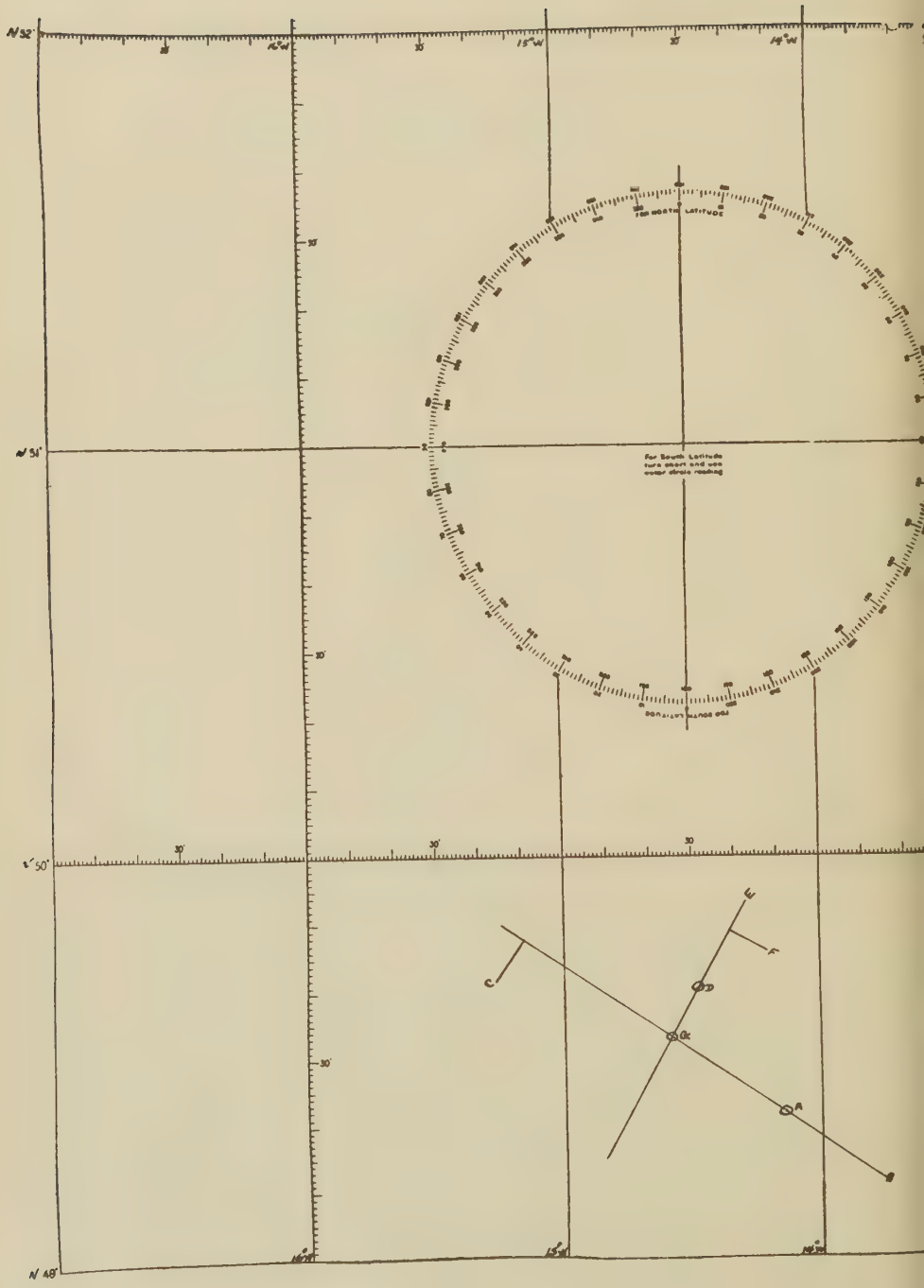
Chron.	7h 17m 15s		
Slow	+ 14m 6s	Dec.	12° 16′ 30″ N
		Lat.	49° 30′ 0″ N
G. C. T. 6d	7h 31m 21s		
S. T. 0h G. T.	4h 58m 24s	Diff.	37° 13′ 30″
Corr.	1m 14s		
		Obs. Alt.	48° 41′ 0″
G. S. T.	12h 30m 59s	Corr. (46)	− 5′ 51″
Long.	− 56m 0s		
		True Alt.	48° 35′ 9″
L. S. T.	11h 34m 59s		
R. A.	10h 5m 2s		
H. A.	1h 29m 57s		

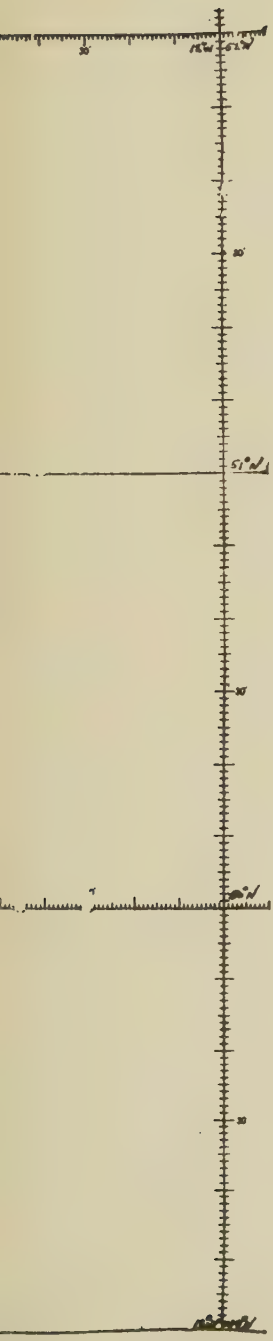
Log. Hav. H. A. 1h 29m 57s = 8.58000
Log. Cos. Lat. 49° 30′ = 9.81254
Log. Cos. Dec. 12° 16′ 30″ = 9.98996

Log. Hav. 8.38250 = Nat. Hav. .02412
Diff. (Lat. Dec.) 37° 13′ 30″ = Nat. Hav. .10187

Nat. Hav. .12599 = Z. D.

Z. D.	41° 35′ 0″	
	90° 0′ 0″	
Com. Alt.	48° 25′ 0″	Azimuth N 146° W or S 34° W
True Alt.	48° 35′ 9″	
Alt. Diff.	+ 10′ 9″	


N 52°
16°W
15°W
14°W
30'
N 51°
N 50°
N 49°
FOR NORTH LATITUDE
For South Latitude turn short and use outer circle reading
FOR SOUTH LATITUDE
C
D
E
F
A
B



Marcq St. Hilaire Method

Problem No. 2

A. Computed position on 1st Sumner line Lat. 49° 21′ 36″ N Long. 14° 8′ 30″ W.

B. 1st Position line, at right angles to true bearing, or N 146° W −90° = N 56° W.

C. True bearing of Regulus N 146° W.

D. Computed position on 2d Sumner line Lat. 49° 40′ 24″ N Long. 14° 28′ 45″ W.

E. 2d Position line, at right angles to true bearing, or N 119° E −90° = N 29° E.

F. True bearing of Arcturus N 119° E.

G. Position of vessel Lat. 49° 33′ N Long. 14° 35′ W.

TO COMPUTE POSITION ON FIRST SUMNER LINE

Since true altitude is greater than computed altitude, the position is nearer to the observed body than dead reckoning position, consequently the altitude difference should be laid off in same direction as azimuth, or S 34° W 10.1 miles from D. R. position.

Table 2 at 34° 10.1 = D. Lat. 8.4 S. Dep. 5.6 D. Long. 8′ 30″ W.

D. R. Position Lat.	49° 30′ 0″ N	Long.	14° 0′ 0″ W
D. Lat. and Long.	8′ 24″ S		8′ 30″ W
Comp. Pos. on 1st Sumner Line	49° 21′ 36″ N		14° 8′ 30″ W

Place this position on chart, and through it draw a line at right angles to azimuth, or N 146° W − 90° = N 56° W. This will be the First Position Line.

As the observations were simultaneous the same D. R. position will be used for Second Observation.

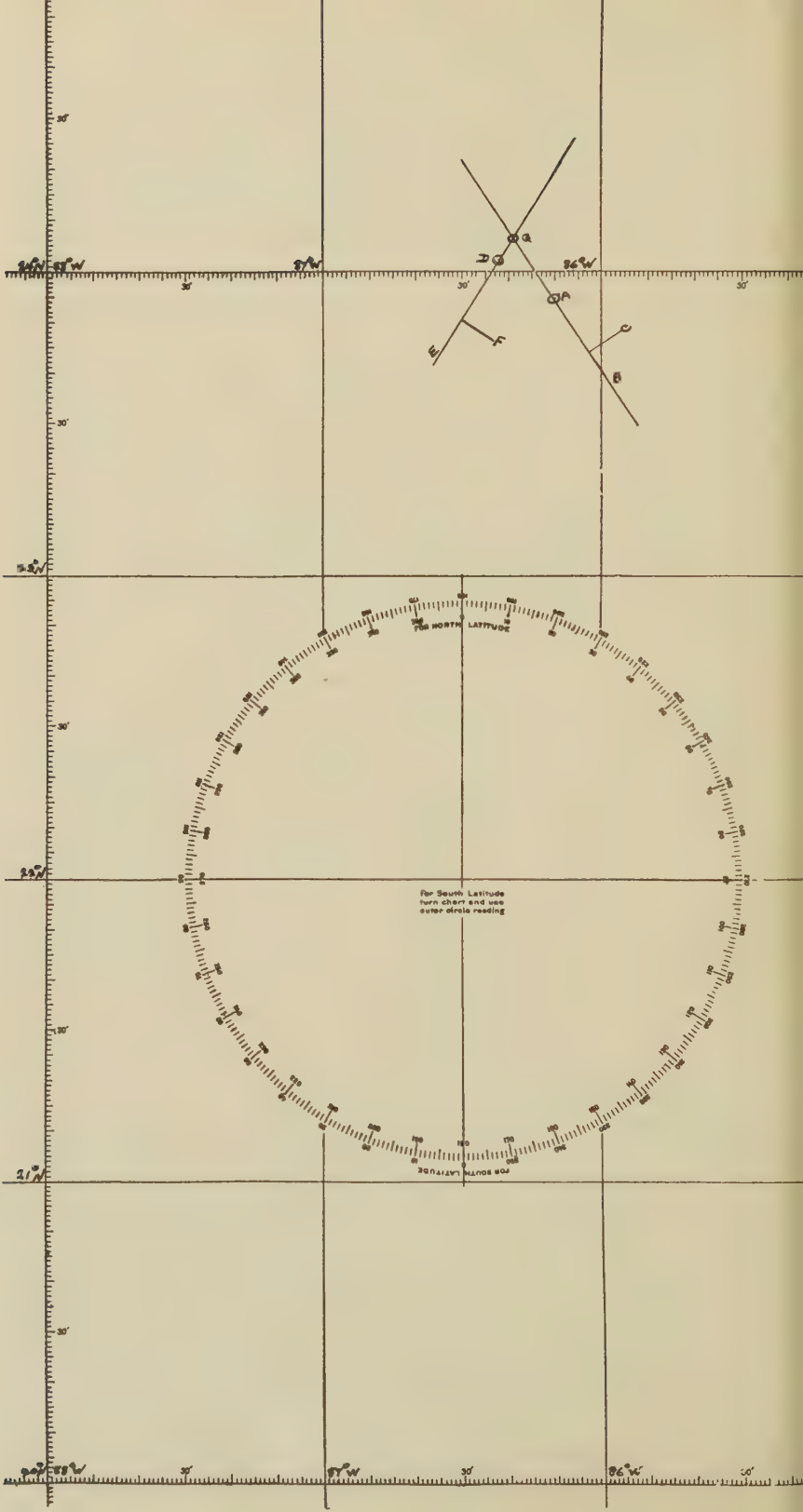
Second Observation, Arcturus E

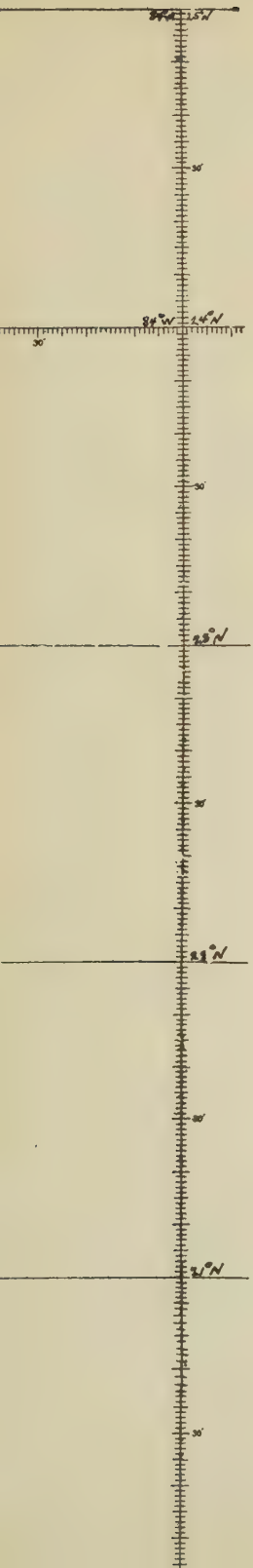
Chron.	7h 18m 37s		
Slow	+ 14m 6s	Dec.	19° 30′ 30″ N
		Lat.	49° 30′ 0″ N
G. C. T. 6d	7h 32m 43s		
S. T. 0h G. T.	4h 58m 24s	Diff.	29° 59′ 30″
Corr.	1m 14s		
		Obs. Alt.	46° 32′ 30″
G. S. T.	12h 32m 21s	Corr. (46)	− 5′ 55″
Long.	− 56m 0s		
		True Alt.	46° 26′ 35″
L. S. T.	11h 36m 21s		
R. A.	14h 12m 47s		
H. A.	2h 36m 26s		

Log. Hav. H. A. 2h 36m 26s = 9.04931
Log. Cos. Lat. 49° 30′ = 9.81254
Log. Cos. Dec. 19° 30′ 30″ = 9.97433

Log. Hav. 8.83618 = Nat. Hav. .06858
Diff. (Lat. Dec.) 29° 59′ 30″ = Nat. Hav. .06695

Nat. Hav. .13553 = Z. D.


FOR NORTH LATITUDE
For South Latitude
turn chart and use
outer circle reading
FOR SOUTH LATITUDE



Marcq St. Hilaire Method

Problem No. 3

A. Computed position on 1st Sumner line projected for course and distance Lat. 23° 55′ N Long. 86° 10′ W.

B. 1st Position line, projected for course and distance. Through computed position at right angles to true bearing, or N 56° E − 90° = N 34° W.

C. Stars true bearing N 56° E.

D. Computed position on 2d Sumner line Lat. 24° 1′ 54″ N Long. 86° 22′ 0″ W.

E. 2d Position line. Through computed position at right angles to true bearing N 122° E − 90° = N 32° E.

F. Sun's true bearing N 122° E.

G. Position of vessel at 2d observation Lat. 24° 6′ N Long. 86° 19′ 0″ W.

Z. D.	43° 12′ 0″	
	90° 0′ 0″	
Comp. Alt.	46° 48′ 0″	Azimuth N 119° E or S 61° E
True Alt.	46° 26′ 35″	
Alt. Diff.	— 21′ 25″	

TO COMPUTE POSITION ON SECOND SUMNER LINE

Since true altitude is less than computed altitude, the azimuth is reversed, or N 61° W 21.4 miles from D. R. position.

Table 2 at 61° 21.4 = D. Lat. 10.4 N. Dep. 18.8 D. Long. 28′ 45″ W.

D. R. Position Lat.	49° 30′ 0″ N	Long. 14° 0′ W
D. Lat. and Long.	10′ 24″ N	28′ 45″ W
Comp. Pos. on 2d Sumner Line	49° 40′ 24″ N	14° 28′ 45″ W

Place this position on chart, and through it draw a line at right angles to azimuth, or N 119° E − 90° = N 29° E. This will be the Second Position Line, and where it crosses the First Position Line will be the ship's position at Second Observation.

See: Chart following this problem.
Sumner's Method with two assumed latitudes, Problem 2.
Sumner's "Tangent" Method, Problem 2.
Double Chronometer Method, Problem 2.

PROBLEM NO. 3

STAR AND SUN IN ADJACENT QUADRANTS

Jan. 9, 1936. At 6.20 A. M. Obs. Alt. *Vega bearing E 24° 33′ 20″. Dip 40 ft. Chron. read 12h 33m 8s P. M., which was fast 34m 55s. D. R. position. Lat. 23° 50′ N. Long. 86° 15″ W.

Same date at 8.05 A. M. Obs. Alt. Sun's L. L. 13° 21′ 37″. Chron. read 2h 16m 8s P. M., fast 34m 56s.

Ship ran in interval between observations 241° (true) 18 miles.

Required position at Second Observation?

First Observation, Vega E

Chron.	12h 33m 8s		
Fast	− 34m 55s	Dec.	38° 43′ 24″ N
		Lat.	23° 50′ 0″ N
G. C. T. 9d	11h 58m 13s		
S. T. 0h G. T.	7h 9m 27s	Diff.	14° 53′ 24″
Corr.	1m 58s		
		Obs. Alt.	24° 33′ 20″
G. S. T.	19h 9m 38s	Corr. (46)	− 8′ 20″
Long.	− 5h 45m 0s		
		True Alt.	24° 25′ 0″
L. S. T.	13h 24m 38s		
R. A.	18h 34m 45s		
H. A.	5h 10m 7s		

Log. Hav. H. A. 5h 10m 7s = 9.59332
Log. Cos. Lat. 23° 50′ = 9.96129
Log. Cos. Dec. 38° 43′ 24″ = 9.89219

Log. Hav. 9.44680 = Nat. Hav. .27977
Diff. (Lat. Dec.) 14° 53′ 24″ = Nat. Hav. .01679

Nat. Hav. .29656 = Z. D.

Z. D.	65° 59′ 30″	
	90° 0′ 0″	
Comp. Alt.	24° 0′ 30″	Azimuth N. 56° E
True Alt.	24° 25′ 0″	
Alt. Diff.	+ 24′ 30″	

TO COMPUTE POSITION ON FIRST SUMNER LINE

Table 2 at N 56° E 24.5 miles = D. Lat. 13.7 N. Dep. 20.3 D. Long. 22′ 15″ E.

1st D. R. Pos. Lat.	23° 50′ 0″ N	Long. 86° 15′ 0″ W
D. Lat. and Long.	13′ 42″ N	22′ 15″ E
Comp. Pos. on 1st Sumner Line	24° 3′ 42″ N	85° 52′ 45″ W

TO COMPUTE POSITION ON FIRST SUMNER LINE PROJECTED FOR COURSE AND DISTANCE

Course 241° Dist. 18 = D. Lat. 8.7 S. Dep. 15.7. D. Long. 17′ 15″ W.

Comp. Pos. on 1st Sumner Line	24° 3′ 42″ N	85° 52′ 45″ W
D. Lat. and Long.	8′ 42″ S	17′ 15″ W
Comp. Pos. on 1st Sumner Line projected	23° 55′ 0″ N	86° 10′ 0″ W

Place this position on chart, and through it draw a line at right angles to azimuth, or N 56° E − 90° = N 34° W. This will be the First Position Line projected.

Above position is also D. R. position for Second Observation.

Second Observation, Sun

D. R. Position Lat. 23° 55′ N; Long. 86° 10′ W.

Chron.	14h 16m 8s	Dec. 9d 12h	22° 13′.7
Fast	− 34m 56s	Corr. for 1.7h	− .5
G. C. T. 9d	13h 41m 12s	Dec. 9d 13.7h	22° 13′.2 S
Eq. Time	− 6m 54s	D. R. Lat.	23° 55′.0 N
G. A. T. 9d	13h 34m 18s	Sum	46° 8′.2
Long.	− 5h 44m 40s		
		Obs. Alt.	13° 21′ 37″
H. A.	7h 49m 38s A. M.	Corr. (46)	+ 6′ 14″
		True Alt.	13° 27′ 51″

Log. Hav. H. A. 7h 49m 38s = 9.43110
Log. Cos. Lat. 23° 55′ = 9.96101
Log. Cos. Dec. 22° 13′ 12″ = 9.96649

Log. Hav. 9.35860 = Nat. Hav. .22835
Sum (Lat. Dec.) 46° 8′ 12″ = Nat. Hav. .15353

Nat. Hav. .38188 = Z. D.

Z. D.	76° 20′ 0″	
	90° 0′ 0″	
Comp. Alt.	13° 40′ 0″	Azimuth N 122° E or S 58° E
True Alt.	13° 27′ 51″	
Alt. Diff.	− 13′ 9″	

TO COMPUTE POSITION ON SECOND SUMNER LINE

Table 2 at N 58° W. Dist. 13.1 = D. Lat. 6.9 N. Dep. 11.0 D. Long. 12′ W.

2d D. R. Pos. Lat.	23°	55′	0″ N	Long. 86°	10′ 0″ W
D. Lat. and Long.		6′	54″ N		12′ 0″ W
Comp. Pos. on 2d Sumner Line	24°	1′	54″ N	86°	22′ 0″ W

Place this position on chart, and through it draw a line at right angles to azimuth, or N 122° E − 90° = N 32° E. This will be the Second Position Line, and where it crosses the First Position Line projected will be the ship's position at Second Observation.

See: Chart following this problem.
Double Chronometer Method, Problem 3.

CHAPTER XLIII

MARCQ ST. HILAIRE METHOD

(H. O. No. 208)

Formula by Lieut. Comm. J. Y. Dreisonstok, U. S. N. The notes on solutions given in his book are very explicit and easy to follow.

A problem is given to illustrate the method, and the chartlet accompanying Chapter XLIV H.O.No. 211 Method will illustrate the plotting of position lines.

Example:

March 4, 1936. 7.30 A. M. at ship. Obs. Alt. Sun's L. L. 13° 21′ 45″. Dip 36 ft. Chron. read 12h 15m 25s P. M., which was slow 2m 8s. D. R. Position Lat. 37° 25′ N. Long. 69° W.

At 10 A. M. another observation of Sun's L. L. was observed 37° 23′. Chron. read 2h 45m P. M.

Ship ran between observations S 84° W (true) 12 knots per hour.

Required position at 2d Observation by H. O. No. 208.

First Observation

Chron.	12h 15m 25s	Dec.	6° 23′.4
Slow	+ 2m 8s	Corr.	− .3
G. C. T. 4d	12h 17m 33s	Dec.	6° 23′.1 S
Eq. T.	− 12m 5s		
G. A. T. 4d	12h 5m 28s	Obs. Alt.	13° 21′ 45″
	−12h 0m 0s	Corr.	+ 6′ 23″
G. H. A.	0h 5m 28s	True Alt. (h)	13° 28′ 8″
Arc.	1° 22′ W		
Ass. Long.	69° 22′ W		
L. H. A. (t)	68° 0′ E		

t..... 68°	dec. d	6° 23′.1 S					
Ass. Lat. 37°	b	26° 26′.0 N	A	17259	C 130	Z′	33°.9
	d+b	20° 2′.9	B	46497	D 438	Z″	74°.9
			A+B	63756	C+D 568	Z N	108°.8 E

hc		13° 19′.1
h		13° 28′.1
Alt. Diff.	+	9′.0

From the assumed position Lat. 37° N Long. 69° 22 W placed on the chart draw a line 9.0 miles in length on the line of azimuth or N 109° E towards the body. At this point, draw a line at right angles to the azimuth. This is the required line of position, or First Position Line.

From the First Position Line allow the course and distance run between First and Second Observations, and draw a line through this point parallel to First Position Line. This will be the First Position Line projected.

Find the D. R. Position for 2d Observation.

1st D. R. Position Lat.	37° 25′ 0″ N	Long.	69° 0′ 0″ W
D. Lat.	3′ 6″ S	D. Long.	37′ 15″ W
2d D. R. Position Lat.	37° 21′ 54″ N	Long.	69° 37′ 15″ W

Course S 84 W
Distance 30 miles
D. Lat. 3.1 S Dep. 29.8
D. Long. 37′ 15″ W

Second Observation

Chron.	14h 45m 0s	Dec.	6° 21′.5
Slow	+ 2m 8s	Corr.	− .8
G. C. T. 4d	14h 47m 8s	Dec.	6° 20′.7 S
Eq. T.	− 11m 50s		
		Obs. Alt.	37° 23′ 0″
G. A. T. 4d	14h 35m 18s	Corr.	+ 9′ 7″
	−12h 0m 0s		
		h	37° 32′ 7″
G. H. A.	2h 35m 18s		
Arc.	38° 49′ 30″ W		
Ass. Long.	69° 49′ 30″ W		
L. H. A. (t)	31° 0′ 0″ E		

t..... 31°	dec. d	6° 20′.7 S					
Ass. Lat. 37°	b	48° 40′.8 N	A	4025	C 386	Z′	70°.1
	d+b	42° 20′.1	B	17168	D 40	Z″	69°.5
			A+B	21193	C+D 426	Z	N 139°.6 E

hc	37° 52′.1	
h	37° 32′.1	
Alt. Diff.	−	20′.0

From the assumed position Lat. 37° N Long. 69° 49′ 30″ W draw on the line of azimuth away from the body a distance of 20.0 miles. At this point draw a line at right angles to the azimuth.

Where this line crosses the projection of the First Position Line will be the position of the vessel at second observation.

See chart (Marcq St. Hilaire H. O. No. 211 Method).

CHAPTER XLIV

MARCQ ST. HILAIRE METHOD

(H. O. No. 211)

Formula by Lieut. A. A. Ageton, U. S. N.

The notes given in H. O. No. 211 on solutions will, if followed closely, illustrate the method perfectly.

A chartlet is given to illustrate the plotting of position lines.

Example:

March 4, 1936. 7.30 A. M. at ship. Obs. Alt. Sun's L. L. 13° 21′ 45″. Dip 36 ft. Chron. read 12h 15m 25s P. M., which was slow 2m 8s. D. R. Position Lat. 37° N Long. 69° 22′ W.

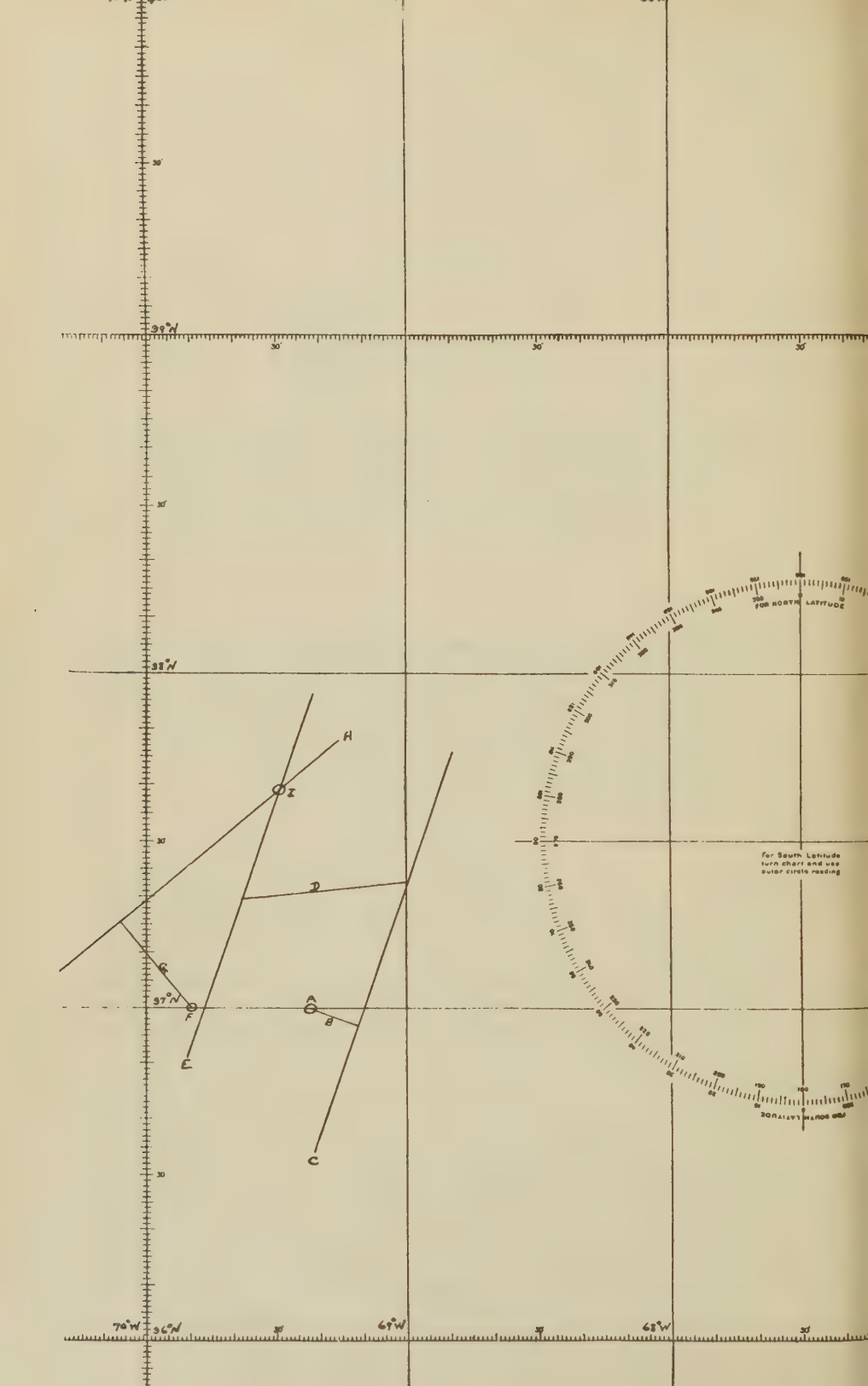
At 10 A. M. another observation of Sun's L. L. was observed 37° 23′ Chron. read 2h 45m P. M. D. R. Position Lat. 37° N Long. 69° 49′ 30″ W

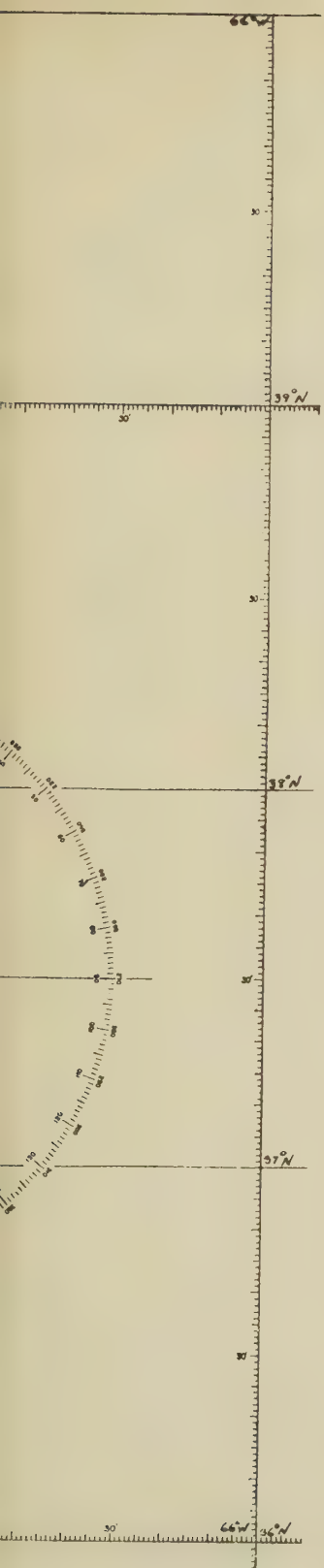
Ship ran between observations S 84° W (true) 30 miles.

Required position at 2d observation by H. O. No. 211.

First Observation

Chron.	12h 15m 25s	Dec.	6° 23′.4
Slow	+ 2m 8s	Corr.	− .3
G. C. T. 4d	12h 17m 33s	Dec.	6° 23′.1 S
Eq. T.	− 12m 5s		
		Obs. Alt.	13° 21′ 45″
G. A. T. 4d	12h 5m 28s	Corr.	+ 6′ 23″
	−12h 0m 0s		
		h	13° 28′ 8″
G. H. A.	0h 5m 28s		
Arc.	1° 22′ W		
D. R. Long.	69° 22′ W		
L. H. A. (t)	68° 0′ E		


39°N
38°N
37°N
36°N
76°W
75°W
74°W
73°W
30'
A
B
C
D
E
F
G
H
Z
For South Latitude
turn chart and use
outer circle reading



Marcq St. Hilaire Method (H. O. No. 211)

Lieut. A. A. Ageton, U. S. N.

A. 1st D. R. Position Lat. 37° N Long. 69° 22′ W.

B. Azimuth N. 109° E 9.0 miles towards the body.

C. First Position Line at right angles to azimuth or N 19° E.

D. Course and distance between observations S 84° W 30 miles.

E. First Position line projected for course and distance.

F. Second D R Position Lat. 37° N Long. 69° 49′ 30″ W.

G. Azimuth N 140° E 20.0 miles away from the body.

H. Second position line at right angles to azimuth or N 50° E.

I. Position of vessel at 2d observation Lat. 37° 39′ 30″ N. Long. 69° 29′ W.

Note: To plot position by H. O. No. 208 the operation would be identical, using D R positions in this example as Assumed Positions.

G. H. A.: Time 0h 5m 28s
G. H. A.: Arc. 1° 22′ W
Long. D. R. 69° 22′ W

		Add	Subtract	Add	Azimuth Subtract
L. H. A. Arc.	68° 0′.0 E	A 3283			
Dec.	6° 23′.1 S	B 270	A 95397		
		A 3553	B 41066	B 41066	A 3553
K	16° 38′ S		A 54331		
Lat. D. R.	37° 0′ N				
K∼L	53° 38′			B 22698	
Hc	13° 19′			A 63764	B 1184
h	13° 28′.1				A 2369
Alt. Diff.	9′.1 (towards)			Az. Z N	108° 46′ E

Second Observation

D. R. Position Lat. 37° N Long. 69° 49′ 30″ W.

Chron.	14h 45m 0s	Dec.	6° 21′.5
Slow	+ 2m 8s	Corr.	− .8
G. C. T. 4d	14h 47m 8s	Dec.	6° 20′.7 S
Eq. T.	− 11m 50s		
		Obs. Alt.	37° 23′ 0″
G. A. T. 4d	14h 35m 18s	Corr.	+ 9′ 7″
	−12h 0m 0s		
		h	37° 32′ 7″
G. H. A..	2h 35m 18s		
Arc.	38° 49′ 30″ W		
D. R. Long.	69° 49′ 30″ W		
L. H. A. (t)	31° 0′ 0″ E		

		Add	Subtract	Add	Azimuth Subtract
L. H. A. Arc.	31° 0′.0 E	A 28816			
Dec.	6° 20′.7 S	B 267	A 95681		
		A 29083	B 6599	B 6599	A 29083
K	7° 23′ S		A 89082		
Lat. D. R.	37° 0′ N				
K∼L	44° 23′			B 14589	
Hc	37° 52′.5			A 21188	B 10273
h	37° 32′.1				A 18810
Alt. Diff. See chart.	20′.4 (away)			Az. Z N	139° 35′ E

CHAPTER XLV

EXTRACTS FROM THE AMERICAN NAUTICAL ALMANAC FOR THE YEAR 1936

SUN, 1936

(Pages 2-3 N. A.)

Siderial Time of 0h Civil Time at Greenwich (R. A. M. S. +12h.)

Jan., 1936

Day	h	m	s
7	7	1	34.4
9	7	9	27.5
12	7	21	17.2
30	8	32	15.2
31	8	36	11.8

Feb., 1936

6	8	59	51.1
9	9	11	40.8
11	9	19	33.9
12	9	23	30.4
15	9	35	20.1
16	9	39	16.6

Mar., 1936

11	11	13	53.9
21	11	53	19.5
31	12	32	45.0

April, 1936

16	13	35	49.9
20	13	51	36.1

May, 1936

Day	h	m	s
2	14	38	54.7
6	14	54	40.9
9	15	6	30.6
17	15	38	3.1
20	15	49	52.7

June, 1936

6	16	56	54.2
8	17	4	47.3
12	17	20	33.6
15	17	32	23.2
24	18	7	52.3

July, 1936

4	18	47	17.8
11	19	14	53.7
13	19	22	46.8
15	19	30	40.0
26	20	14	2.1

Aug., 1936

6	20	57	24.2
15	21	32	53.2
16	21	36	49.8
28	22	24	8.4

Sept., 1936

Day	h	m	s
8	23	7	30.5
9	23	11	27.0
16	23	39	2.9

Oct., 1936

6	0	57	54.0
12	1	21	33.3
13	1	25	29.8
16	1	37	19.5
18	1	45	12.6
25	2	12	48.5
28	2	24	38.1

Nov., 1936

10	3	15	53.4
23	4	7	8.6
27	4	22	54.8

Dec., 1936

1	4	38	41.1
6	4	58	23.8
9	5	10	13.5
16	5	37	49.4
26	6	17	15.0

Table at bottom of pages 2-3, Nautical Almanac, "Correction for Longitude from Greenwich" is constant, and can be used for any year.

SUN, 1936
(Pages 4-39, N. A.)
DECLINATION AND EQUATION OF TIME
JANUARY, 1936

G. C. T.	Equation of Time	Sun's Declination
	Thursday, 2	
h	m s	° ′
4	− 3 34.1	−23 1.5
6	3 36.5	23 1.1
8	3 38.9	23 0.7
10	3 41.2	23 0.3
12	3 43.6	22 59.9
14	3 45.9	22 59.4
H. D.	1.2	0.2
	Thursday, 9	
8	− 6 47.5	−22 15.1
10	6 49.6	22 14.4
12	6 51.7	22 13.7
14	6 53.8	22 13.0
H. D.	1.1	0.3
	Saturday, 11	
8	− 7 37.1	−21 58.0
10	7 39.1	21 57.3
12	7 41.1	21 56.5
H. D.	1.0	0.4
	Tuesday, 14	
8	− 8 47.2	−21 29.3
10	8 49.1	21 28.5
12	8 51.0	21 27.6
H. D.	0.9	0.4
	Saturday, 18	
8	−10 12.0	−20 45.2
10	10 13.7	20 44.2
12	10 15.3	20 43.2
H. D.	0.8	0.5
	Friday, 24	
h	m s	° ′
20	−12 5.8	−19 20.2
22	12 7.0	19 19.0
H. D.	0.6	0.6
	Saturday, 25	
0	−12 8.3	−19 17.8
H. D.	0.6	0.6
	Thursday, 30	
12	−13 17.9	−17 53.8
14	13 18.8	17 52.4
16	13 19.7	17 51.1
18	13 20.5	17 49.7
20	13 21.3	17 48.4
22	13 22.2	17 47.1
H. D.	0.4	0.7
	Friday, 31	
0	−13 23.0	−17 45.7
2	13 23.8	17 44.3
8	13 26.3	17 40.2
10	13 27.1	17 38.8
12	13 27.9	17 37.5
14	13 28.7	17 36.1
16	13 29.5	17 34.7
18	13 30.3	17 33.3
20	13 31.0	17 31.9
22	13 31.8	17 30.6
H. D.	0.4	0.7

SEMIDIAMETER

	′
Jan. 1	16.30
11	16.30
21	16.28
31	16.27

NOTE.—The equation of time is to be applied to the G. C. T. in accordance with the sign as given.

FEBRUARY, 1936

G. C. T.	Equation of Time	Sun's Declination
	Saturday, 1	
h	m s	° ′
0	−13 32.6	−17 29.2
2	13 33.3	17 27.8
4	13 34.1	17 26.4
6	13 34.8	17 25.0
8	13 35.6	17 23.6
H. D.	0.4	0.7
	Sunday, 2	
6	−13 43.3	−17 8.1
8	13 44.0	17 6.7
10	13 44.7	17 5.3
12	13 45.3	17 3.8
H. D.	0.3	0.7
	Friday, 7	
16	−14 14.9	−15 31.6
18	14 15.2	15 30.1
20	14 15.5	15 28.5
H. D.	0.2	0.8
	Sunday, 9	
18	−14 20.7	−14 52.4
20	14 20.9	14 50.8
22	14 21.1	14 49.2
H. D.	0.1	0.8
	Tuesday, 11	
8	−14 22.9	−14 21.8
10	14 22.9	14 20.2
12	14 23.0	14 18.6
H. D.	0.0	0.8

G. C. T.	Equation of Time	Sun's Declination
	Wednesday, 12	
h	m s	° ′
0	−14 23.2	−14 8.8
2	14 23.2	14 7.1
8	14 23.2	14 2.2
10	14 23.2	14 0.6
12	14 23.2	13 58.9
14	14 23.2	13 57.3
H. D.	0.0	0.8
	Monday, 24	
0	−13 34.6	− 9 58.0
2	13 34.0	9 56.2
H. D.	0.3	0.9
	Thursday, 27	
4	−13 6.1	− 8 47.7
6	13 5.2	8 45.8
8	13 4.4	8 44.0
H. D.	0.4	0.9

SEMIDIAMETER

	′
Feb. 1	16.26
11	16.24
21	16.20
Mar. 2	16.17

MARCH, 1936

G. C. T.	Equation of Time	Sun's Declination
	Tuesday, 3	
h	m s	° ′
12	−12 5.0	− 6 46.5
14	12 4.0	6 44.6
16	12 2.9	6 42.7
H. D.	0.5	1.0

G. C. T.	Equation of Time	Sun's Declination
	Wednesday, 4	
h	m s	° ′
10	−11 53.1	− 6 25.4
12	11 52.0	6 23.4
14	11 50.9	6 21.5
16	11 49.7	6 19.6
H. D.	0.6	1.0

MARCH, 1936—*Cont.*

G. C. T.	Equation of Time	Sun's Declination
	Tuesday, 10	
h	m s	° ′
10	−10 25.9	− 4 5.5
12	10 24.6	4 3.5
14	10 23.3	4 1.6
16	10 22.0	3 59.6
18	10 20.7	3 57.7
20	10 19.4	3 55.7
H. D.	0.7	1.0
	Wednesday, 11	
0	−10 16.8	− 3 51.8
2	10 15.4	3 49.8
4	10 14.1	3 47.8
6	10 12.8	3 45.9
8	10 11.5	3 43.9
10	10 10.1	3 42.0
12	10 8.8	3 40.0
H. D.	0.7	1.0

SEMIDIAMETER	
	′
Mar. 1	16.17
11	16.13
21	16.08
31	16.04

G. C. T.	Equation of Time	Sun's Declination
	Friday, 20	
h	m s	° ′
2	− 7 42.7	− 0 16.8
4	7 41.2	0 14.8
6	7 39.7	0 12.8
16	7 32.3	0 2.9
18	7 30.8	0 1.0
20	7 29.3	+ 0 1.0
H. D.	0.7	1.0
	Saturday, 21	
6	− 7 21.9	+ 0 10.9
8	7 20.4	0 12.9
10	7 18.9	0 14.8
12	7 17.4	0 16.8
14	7 15.9	0 18.8
16	7 14.4	0 20.8
18	7 12.9	0 22.8
H. D.	0.7	1.0
	Sunday, 22	
0	− 7 8.4	+ 0 28.7
H. D.	0.8	1.0

APRIL, 1936

G. C. T.	Equation of Time	Sun's Declination
	Friday, 3	
h	m s	° ′
8	− 3 24.4	+ 5 17.4
10	3 22.9	5 19.3
12	3 21.4	5 21.2
H. D.	0.7	1.0
	Saturday, 18	
2	+ 0 33.3	+10 43.1
4	0 34.4	10 44.8
6	0 35.5	10 46.6
8	0 36.7	10 48.3
H. D.	0.6	0.9

G. C. T.	Equation of Time	Sun's Declination
	Sunday, 19	
h	m s	° ′
0	+ 0 45.6	+11 2.2
2	0 46.7	11 4.0
4	0 47.8	11 5.7
6	0 48.9	11 7.4
8	0 50.0	11 9.2
10	0 51.1	11 10.9
12	0 52.2	11 12.6
H. D.	0.5	0.9
	Wednesday, 22	
22	+ 1 34.5	+12 22.4
H. D.	0.5	0.8

APRIL, 1936—*Cont.*

G. C. T.	Equation of Time	Sun's Declination
	Thursday, 23	
h	m s	° ′
0	+ 1 35.4	+12 24.0
2	1 36.4	12 25.7
14	1 42.1	12 35.7
16	1 43.0	12 37.4
18	1 44.0	12 39.0
20	1 44.9	12 40.7
22	1 45.8	12 42.3
H. D.	0.5	0.8

G. C. T.	Equation of Time	Sun's Declination
	Friday, 24	
h	m s	° ′
0	+ 1 46.8	+12 44.0
2	1 47.7	12 45.6
H. D.	0.5	0.8

SEMIDIAMETER

	′
April 1	16.03
11	15.99
21	15.94
May 1	15.90

MAY, 1936

G. C. T.	Equation of Time	Sun's Declination
	Sunday, 3	
h	m s	° ′
6	+ 3 8.9	+15 37.9
8	3 9.4	15 39.4
10	3 10.0	15 40.8
H. D.	0.3	0.7
	Wednesday, 6	
10	+ 3 26.8	+16 32.5
12	3 27.2	16 33.9
14	3 27.6	16 35.3
H. D.	0.2	0.7

G. C. T.	Equation of Time	Sun's Declination
	Thursday, 28	
h	m s	° ′
14	+ 2 52.3	+21 29.6
16	2 51.7	21 30.4
18	2 51.0	21 31.2
H. D.	0.3	0.4
	Friday, 29	
12	+ 2 45.3	+21 38.2
14	2 44.7	21 39.0
16	2 44.0	21 39.7
H. D.	0.3	0.4

SEMIDIAMETER

	′		′
May 1	15.90	May 21	15.83
11	15.86	31	15.80

JUNE, 1936

G. C. T.	Equation of Time	Sun's Declination
	Saturday, 13	
h	m s	° ′
0	+ 0 15.3	+23 11.6
2	0 14.2	23 11.9
H. D.	0.5	0.1

SEMIDIAMETER

	′
June 1	15.80
11	15.78
21	15.77
July 1	15.76

JULY, 1936

G. C. T.	Equation of Time	Sun's Declination
	Friday, 3	
h	m s	° ′
14	− 4 2.8	+22 57.4
16	4 3.7	22 56.9
18	4 4.6	22 56.5
H. D.	0.5	0.2
	Saturday, 4	
12	− 4 12.6	+22 52.7
14	4 13.5	22 52.3
16	4 14.4	22 51.8
18	4 15.3	22 51.4
20	4 16.2	22 50.9
22	4 17.0	22 50.5
H. D.	0.4	0.2
	Sunday, 5	
0	− 4 17.9	+22 50.0
2	4 18.8	22 49.6
4	4 19.7	22 49.1
6	4 20.5	22 48.6
8	4 21.4	22 48.2
10	4 22.2	22 47.7
12	4 23.1	22 47.2
H. D.	0.4	0.2

G. C. T.	Equation of Time	Sun's Declination
	Sunday, 12	
h	m s	° ′
10	− 5 25.5	+21 58.8
12	5 26.1	21 58.1
14	5 26.7	21 57.4
16	5 27.4	21 56.7
18	5 28.0	21 56.0
H. D.	0.3	0.3
	Tuesday, 14	
8	− 5 39.3	+21 42.1
10	5 39.8	21 41.4
12	5 40.4	21 40.6
H. D.	0.3	0.4

SEMIDIAMETER

	′
July 1	15.76
11	15.76
21	15.77
31	15.79

AUGUST, 1936

G. C. T.	Equation of Time	Sun's Declination
	Saturday, 8	
h	m s	° ′
8	− 5 31.9	+16 10.4
10	5 31.2	16 9.0
12	5 30.6	16 7.6
14	5 29.9	16 6.2
H. D.	0.3	0.7
	Tuesday, 11	
8	− 5 6.2	+15 18.2
10	5 5.4	15 16.7
12	5 4.6	15 15.3
H. D.	0.4	0.7

G. C. T	Equation of Time	Sun's Declination
	Monday, 17	
h	m s	° ′
6	− 4 1.1	+13 28.9
8	4 0.1	13 27.3
10	3 59.0	13 25.7
H. D.	0.5	0.8
	Sunday, 30	
18	− 0 29.3	+ 8 53.2
20	0 27.7	8 51.5
22	0 26.2	8 49.7
H. D.	0.8	0.9

SEMIDIAMETER

	′		′
Aug. 1	15.79	Aug. 21	15.84
11	15.81	31	15.88

SEPTEMBER, 1936

G. C. T.	Equation of Time	Sun's Declination
	Thursday, 3	
h	m s	° ′
2	+ 0 33.9	+ 7 40.7
4	0 35.5	7 38.9
6	0 37.2	7 37.1
H. D.	0.8	0.9
	Friday, 18	
4	+ 5 45.6	+ 1 58.0
6	5 47.3	1 56.1
8	5 49.1	1 54.2
H. D.	0.9	1.0
	Wednesday, 23	
0	+ 7 27.7	+ 0 5.3
2	7 29.4	0 3.4
4	7 31.2	+ 0 1.4
6	7 32.9	− 0 0.5
8	7 34.6	0 2.5
10	7 36.4	0 4.4
H. D.	0.9	1.0
	Thursday, 24	
h	m s	° ′
10	+ 7 57.2	− 0 27.8
12	7 59.0	0 29.8
14	8 0.7	0 31.7
H. D.	0.9	1.0
	Wednesday, 30	
18	+10 5.4	− 2 55.8
20	10 7.0	2 57.8
22	10 8.6	2 59.7
H. D.	0.8	1.0

SEMIDIAMETER

	′
Sept. 1	15.88
11	15.92
21	15.96
Oct. 1	16.01

OCTOBER, 1936

G. C. T.	Equation of Time	Sun's Declination
	Saturday, 3	
h	m s	° ′
10	+10 56.4	− 3 57.8
12	10 58.0	3 59.8
14	10 59.6	4 1.7
H. D.	0.8	1.0
	Monday, 5	
20	+11 40.6	− 4 53.8
22	11 42.1	4 55.7
H. D.	0.7	1.0
	Sunday, 11	
10	+13 13.4	− 7 1.6
12	13 14.6	7 3.4
14	13 15.9	7 5.3
H. D.	0.6	0.9
	Saturday, 17	
20	+14 40.6	− 9 24.7
22	14 41.6	9 26.5
H. D.	0.5	0.9
	Sunday, 18	
0	+14 42.6	− 9 28.4
2	14 43.6	9 30.2
H. D.	0.5	0.9

G. C. T.	Equation of Time	Sun's Declination
	Thursday, 22	
h	m s	° ′
10	+15 28.2	−11 3.6
12	15 29.0	11 5.7
14	15 29.7	11 7.2
H. D.	0.4	0.9
	Friday, 23	
14	+15 38.1	−11 28.3
16	15 38.8	11 30.0
18	15 39.5	11 31.8
20	15 40.1	11 33.5
22	15 40.8	11 35.3
H. D.	0.3	0.9
	Saturday, 24	
0	+15 41.5	−11 37.0
2	15 42.1	11 38.8
4	15 42.8	11 40.5
6	15 43.4	11 42.2
8	15 44.1	11 44.0
10	15 44.7	11 45.7
12	15 45.3	11 47.5
14	15 45.9	11 49.2
H. D.	0.3	0.9

SEMIDIAMETER

Oct. 1	16.01
11	16.06
21	16.10
31	16.15

NOVEMBER, 1936

G. C. T.	Equation of Time	Sun's Declination
	Saturday, 7	
h	m s	° ′
18	+16 15.5	−16 23.3
20	16 15.1	16 24.7
22	16 14.8	16 26.2
H. D.	0.1	0.7
	Sunday, 15	
6	+15 23.3	−18 27.2
8	15 22.5	18 28.5
10	15 21.6	18 29.8
12	15 20.7	18 31.1
14	15 19.9	18 32.3
H. D.	0.4	0.6
	Sunday, 22	
22	+13 41.4	−20 15.0
H. D.	0.7	0.5
	Monday, 23	
0	+13 40.0	−20 16.1
2	13 38.7	20 17.2
H. D.	0.7	0.5

G. C. T.	Equation of Time	Sun's Declination
	Saturday, 28	
h	m s	° ′
6	+12 3.7	−21 17.3
8	12 2.0	21 18.2
10	12 0.3	21 19.0
H. D.	0.9	0.4
	Monday, 30	
18	+11 10.9	−21 42.6
20	11 9.1	21 43.4
22	11 7.2	21 44.1
H. D.	0.9	0.4

SEMIDIAMETER

Nov. 1	16.15
11	16.19
21	16.22
Dec. 1	16.25

DECEMBER, 1936

G. C. T.	Equation of Time	Sun's Declination
	Thursday, 3	
h	m s	° ′
6	+10 13.9	−22 5.2
8	10 12.0	22 6.0
10	10 10.0	22 6.7
H. D.	1.0	0.4
	Tuesday, 8	
6	+ 8 8.7	−22 42.6
8	8 6.5	22 43.1
10	8 4.3	22 43.6
H. D.	1.1	0.3
	Monday, 14	
0	+ 5 29.8	−23 11.7
2	5 27.4	23 12.0
4	5 25.0	23 12.3
H. D.	1.2	0.1
	Tuesday, 15	
14	+ 4 44.0	−23 17.1
16	4 41.6	23 17.3
18	4 39.2	23 17.6
H. D.	1.2	0.1

G. C. T.	Equation of Time	Sun's Declination
	Wednesday, 16	
h	m s	° ′
12	+ 4 17.2	−23 19.7
14	4 14.8	23 19.9
16	4 12.4	23 20.1
H. D.	1.2	0.1
	Friday, 25	
0	+ 0 4.1	−23 24.7
2	+ 0 1.6	23 24.6
4	− 0 0.8	23 24.5
10	0 8.3	23 24.1
12	0 10.8	23 24.0
14	0 13.3	23 23.8
H. D.	1.2	0.1

SEMIDIAMETER

	′
Dec. 1	16.25
11	16.28
21	16.29
31	16.30

APPARENT PLACES OF STARS, 1936
FOR THE UPPER TRANSIT AT GREENWICH

No.	Constellation Name	Right Ascension												
			Jan. 1	Feb. 1	Mar. 1	April 1	May 1	June 1	July 1	Aug. 1	Sept. 1	Oct. 1	Nov. 1	Dec. 1	Dec. 32
		h m	s	s	s	s	s	s	s	s	s	s	s	s	s
10	α Tauri	4 32	17.1	16.9	16.4	15.9	15.7	15.8	16.4	17.2	18.2	19.1	19.8	20.4	20.6
11	β Orionis	5 11	29.9	29.8	29.3	28.8	28.4	28.4	28.8	29.5	30.3	31.2	32.0	32.5	32.8
12	α Aurigae	5 11	60.7	60.6	60.0	59.2	58.8	58.8	59.3	60.4	61.6	62.8	64.0	64.8	65.3
15	α Orionis	5 51	44.8	44.8	44.4	43.9	43.5	43.4	43.7	44.4	45.3	46.1	47.0	47.6	48.1
17	α Can. Maj.	6 42	22.0	22.1	21.7	21.1	20.6	20.4	20.5	21.0	21.7	22.5	23.4	24.2	24.7
18	ε Can. Maj.	6 56	8.9	8.9	8.6	7.9	7.3	7.0	7.0	7.4	8.1	8.9	9.9	10.8	11.3
19	α Can. Min.	7 35	59.6	59.8	59.7	59.2	58.8	58.5	58.5	58.8	59.5	60.2	61.2	62.0	62.7
25	α Leonis	10 4	59.9	60.6	60.9	60.8	60.4	60.0	59.8	59.7	59.9	60.3	61.1	62.1	63.1
33	α Virginis	13 21	49.8	50.9	51.6	52.1	52.3	52.3	52.0	51.7	51.4	51.2	51.5	52.1	53.1
35	α Boötis	14 12	44.8	45.8	46.7	47.3	47.6	47.6	47.4	47.0	46.5	46.2	46.2	46.7	47.5
40	α Scorpii	16 25	28.7	29.6	30.7	31.6	32.4	32.9	33.1	32.9	32.5	32.0	31.7	31.8	32.4
47	α Lyræ	18 34	45.1	45.6	46.4	47.5	48.5	49.2	49.7	49.6	49.1	48.5	47.6	47.3	47.2
48	σ Sagittarii	18 51	17.6	18.2	19.0	20.0	21.0	21.9	22.5	22.7	22.5	22.0	21.4	21.2	21.3

No.	Special Name	Declination												
			Jan. 1	Feb. 1	Mar. 1	April 1	May 1	June 1	July 1	Aug. 1	Sept. 1	Oct. 1	Nov. 1	Dec. 1	Dec. 32
		°	′	′	′	′	′	′	′	′	′	′	′	′	′
10	Aldebaran	+16	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.1	23.1	23.1	23.1	23.1
11	Rigel	− 8	16.4	16.5	16.6	16.6	16.5	16.4	16.4	16.3	16.2	16.2	16.2	16.3	16.4
12	Capella	+45	56.2	56.3	56.3	56.3	56.2	56.2	56.1	56.1	56.0	56.1	56.1	56.2	56.2
15	Betelgeux	+ 7	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.9	23.9	23.9	23.9	23.8	23.8
17	Sirius	−16	37.7	37.8	37.9	37.9	37.9	37.8	37.7	37.6	37.5	37.5	37.6	37.7	37.8
18	Adhara	−28	53.0	53.2	53.3	53.3	53.3	53.2	53.1	53.0	52.9	52.8	52.9	53.0	53.2
19	Procyon	+ 5	23.4	23.3	23.3	23.2	23.3	23.3	23.3	23.3	23.4	23.3	23.3	23.2	23.1
25	Regulus	+12	16.7	16.6	16.6	16.6	16.6	16.7	16.7	16.7	16.7	16.6	16.6	16.5	16.4
33	Spica	−10	49.7	49.8	49.9	50.0	50.0	50.0	50.0	49.9	49.9	49.9	49.9	50.0	50.0
35	Arcturus	+19	30.7	30.6	30.5	30.5	30.6	30.7	30.8	30.8	30.8	30.7	30.6	30.5	30.4
40	Antares	−26	17.5	17.5	17.6	17.6	17.6	17.7	17.7	17.7	17.7	17.6	17.6	17.6	17.6
47	Vega	+38	43.4	43.2	43.1	43.1	43.1	43.3	43.4	43.6	43.7	43.7	43.7	43.6	43.5
48	Nunki	−26	22.7	22 7	22.7	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6
54	Fomalhaut	−29	57.8	57.7	57.7	57.6	57.5	57.4	57.3	57.2	57.3	57.3	57.4	57.4	57.4

TABLE I

(Page 262, N. A.)

CORRECTION TO BE APPLIED TO TRUE ALTITUDE OF POLARIS

Local S. T.	1h	7h	8h	9h	10h
m	° ′	° ′	° ′	° ′	° ′
0	−1 1.2 4	−0 10.4 27	+0 5.8 28	+0 21.6 26	+0 35.9 22
10	1 1.6 3	0 7.7 26	0 8.6 26	0 24.2 24	0 38.1 21
20	1 1.9 2	0 5.1 27	0 11.2 26	0 26.6 24	0 40.2 20
30	−1 2.1 1	−0 2.4 28	+0 13.8 27	+0 29.0 24	+0 42.2 20
40	1 2.2 1	+0 0.4 27	0 16.5 25	0 31.4 23	0 44.2 18
50	1 2.1 2	0 3.1 27	0 19.0 26	0 33.7 22	0 46.0 17
60	−1 1.9	+0 5.8	+0 21.6	+0 35.9	+0 47.7

Local S.T.	11h	12h	13h	14h	21h	23h
m	° ′	° ′	° ′	° ′	° ′	° ′
0	+0 47.7 17	+0 56.4 11	+1 1.2 4	+1 1.9 3	−0 20.6 26	−0 47.3 17
10	0 49.4 16	0 57.5 9	1 1.6 3	1 1.6 4	0 23.2 24	0 49.0 16
20	0 51.0 15	0 58.4 9	1 1.9 2	1 1.2 4	0 25.6 25	0 50.6 16
30	+0 52.5 14	+0 59.3 8	+1 2.1 1	+1 0.8 7	−0 28.1 25	−0 52.2 14
40	0 53.9 13	1 0.1 6	1 2.2 1	1 0.1 7	0 30.6 23	0 53.6 13
50	0 55.2 12	1 0.7 5	1 2.1 2	0 59.4 9	0 32.9 22	0 54.9 13
60	+0 56.4	+1 1.2	+1 1.9	+0 58.5	−0 35.1	−0 56.2

MERIDIAN TRANSIT OF STARS, 1936
GREENWICH CIVIL TIME OF TRANSIT AT GREENWICH

Constellation Name	Date	G. C. T. of Transit
b Orionis	Feb. 1	20h 28m
	Nov. 1	2h 31m
a Aurigae	Dec. 1	0h 33m
a Orionis	Mar. 1	19h 14m
a Argus	June 1	13h 43m
a Can. Maj.	May 1	16h 5m
	Dec. 1	2h 3m
a Can. Min.	Feb. 1	22h 52m
a Virginis	Jan. 1	6h 43m
	Feb. 1	4h 41m
	July 1	18h 43m
a Scorpii	Mar. 1	5h 50m
a Boötis	Mar. 1	3h 38m

CORRECTIONS TO BE APPLIED TO THE CIVIL TIME OF TRANSIT ON THE FIRST DAY OF THE MONTH, TO FIND THE CIVIL TIME OF TRANSIT ON ANY OTHER DAY OF THE MONTH.

Day of Month	Correction	Day of Month	Correction
1	0h 0m	17	−1h 3m
2	−0h 4m	18	1h 7m
3	0h 8m	19	1h 11m
4	0h 12m	20	1h 15m
5	0h 16m	21	1h 19m
6	−0h 20m	22	−1h 23m
7	0h 24m	23	1h 27m
8	0h 28m	24	1h 30m
9	0h 31m	25	1h 34m
10	0h 35m	26	−1h 38m
11	−0h 39m	27	1h 42m
12	0h 43m	28	1h 46m
13	0h 47m	29	1h 50m
14	0h 51m	30	1h 54m
15	0h 55m	31	−1h 58m
16	−0h 59m		

NOTE.—If the quantity taken from this table is greater than the civil time of transit on the first of the month, increase that time by 23h 56m and then apply the correction taken from this table.

MOON, 1936

Right Ascension and Declination

(Pages 40-131, N. A.)

G. C. T.	Right Ascension	Declination	S.D.	H.P.
	January 7			
h	h m s	° ′	′	′
0	5 34 23	+25 0.4		
1	5 36 51	24 58.9		
2	5 39 18	24 57.2		
0 7d			15.7	57.4
0 8d			15.5	56.9
	February 12			
2	12 39 37	− 9 52.3		
3	12 41 28	10 3.8		
4	12 43 18	10 15.4		
0 12d			14.8	54.1
0 13d			14.8	54.2
	March 12			
1	13 56 20	−16 49.9		
2	13 58 18	16 59.2		
3	14 0 16	17 8.5		
0 12d			14.8	54.1
0 13d			14.9	54.4
	March 18			
6	19 27 34	−20 56.5		
7	19 29 55	20 48.5		
8	19 32 16	20 40.4		
0 18d			15.8	57.8
0 19d			16.0	58.8
	March 31			
18	8 17 21	+17 33.7		
19	8 19 25	17 24.3		
20	8 21 28	17 14.9		
0 31d			15.3	56.0
0 1d			15.1	55.4
	April 18			
8	22 50 7	− 2 23.9		
9	22 52 22	2 8.7		
10	22 54 36	1 53.5		
0 18d			16.4	60.1
0 19d			16.6	60.8
	April 20			
14	0 54 32	+11 12.4		
15	0 56 56	11 26.5		
16	0 59 20	11 40.6		
0 20d			16.7	61.2
0 21d			16.7	61.3
	April 21			
h	h m s	° ′	′	′
10	1 43 23	+15 39.1		
11	1 45 52	15 51.4		
12	1 48 22	16 3.6		
0 21d			16.7	61.3
0 22d			16.7	61.1
	May 2			
13	11 41 37	− 3 30.4		
14	11 43 25	3 42.5		
15	11 45 13	3 54.5		
0 2d			14.8	54.1
0 3d			14.7	54.0
	May 17			
21	0 48 6	+10 40.4		
22	0 50 25	10 54.2		
23	0 52 45	11 8.0		
0 17d			16.4	60.1
0 18d			16.5	60.5
	May 21			
11	4 25 8	+23 55.0		
12	4 27 47	23 57.8		
13	4 30 26	24 0.4		
0 21d			16.4	60.2
0 22d			16.3	59.6
	June 24			
15	10 33 48	+ 3 53.4		
16	10 35 40	3 40.9		
17	10 37 32	3 28.4		
0 24d			15.1	55.5
0 25d			15.0	54.9
	July 4			
9	18 33 59	−22 49.3		
10	18 36 20	22 44.3		
11	18 38 41	22 39.1		
12	18 41 2	22 33.9		
0 4d			15.5	56.7
0 5d			15.6	57.3
	July 12			
5	1 31 25	+14 45.9		
6	1 33 43	14 57.7		
7	1 36 2	15 9.4		
0 12d			16.2	59.3
0 13d			16.2	59.3

MOON, 1936.—*Cont.*

G. C. T.	Right Ascension	Declination	S.D.	H.P.
	July 13			
h	h m s	° ′	′	′
14	2 49 48	+20 22.1		
15	2 52 14	20 30.3		
16	2 54 41	20 38.4		
0 13d			16.2	59.3
0 14d			16.1	59.1
	July 26			
9	13 50 53	−16 18.7		
10	13 52 50	16 28.0		
11	13 54 48	16 37.1		
0 26d			14.8	54.2
0 27d			14.8	54.4
	August 15			
12	8 18 56	+16 56.8		
13	8 21 5	16 47.0		
14	8 23 14	16 37.1		
0 15d			15.5	56.8
0 16d			15.4	56.3
	September 8			
4	4 57 22	+23 57.7		
5	4 59 53	23 58.4		
6	5 2 24	23 58.9		
0 8d			16.0	58.6
0 9d			15.8	57.9
	September 9			
20	6 35 26	+22 30.9		
21	6 37 48	22 25.9		
22	6 40 10	22 20.8		
0 9d			15.8	57.9
0 10d			15.6	57.3

G. C. T.	Right Ascension	Declination	S.D.	H.P
	October 12			
h	h m s	° ′	′	′
0	10 41 27	+ 3 4.9		
1	10 43 19	2 52.7		
16	11 11 1	− 0 9.1		
17	11 12 51	0 21.2		
18	11 14 41	0 33.3		
0 12d			14.9	54.8
0 13d			14.9	54.4
	November 23			
2	22 52 0	− 1 39.0		
3	22 54 7	1 25.2		
4	22 56 15	1 11.3		
0 23d			16.0	58.7
0 24d			16.2	59.5
	December 6			
5	11 11 2	− 0 27.4		
6	11 12 54	0 39.5		
7	11 14 45	0 51.7		
0 6d			15.1	55.2
0 7d			14.9	54.6
	December 9			
7	13 29 2	−14 10.8		
8	13 30 57	14 20.3		
9	13 32 52	14 29.8		
20	13 54 13	16 10.1		
21	13 56 10	16 18.8		
22	13 58 8	16 27.5		
0 9d			14.8	54.1
0 10d			14.8	54.0

MOON, 1936

Time of Transit, Meridian of Greenwich

(Pages 135-136, N. A.)

Date	Greenwich Civil Time	Variation per hour	Date	Greenwich Civil Time	Variation per hour
	h m	m		h m	m
Jan. 27	14 59	2.1	10	1 16	1.7
28	15 50	2.1	11	1 58	1.8
29	16 41	2.2	April 15	6 33	2.2
Feb. 10	1 57	1.7	16	7 25	2.1
11	2 37	1.7	17	8 16	2.1
12	3 18	1.7	18	9 7	2.1
17	7 16	2.3	19	10 0	2.2
18	8 11	2.3	June 15	8 19	2.3
Mar. 7	23 55	1.7	16	9 16	2.4
9	0 36	1.7	17	10 16	2.5

VENUS, 1936

GREENWICH CIVIL TIME

(Pages 138-141, N. A.)

Date	Apparent Right Ascension	Apparent Declination	Transit, Meridian of Greenwich	Date	Apparent Right Ascension	Apparent Declination	Transit, Meridian of Greenwich
	0h	0h			0h	0h	
Jan.	h m s	° ′	h m	July	h m s	° ′	h m
1	15 40 54	−17 6.4	9 3	10	7 29 8	+22 45.3	12 19
2	15 45 42	17 23.5	9 4	11	7 34 25	22 35.7	12 20
3	15 50 31	17 40.2	9 5	12	7 39 42	22 25.4	12 22
23	17 30 55	21 36.9	9 27	Aug.			
24	17 36 6	21 43.0	9 28	15	10 28 50	+11 5.8	12 56
25	17 41 18	21 48.6	9 29	16	10 33 30	10 38.4	12 57
Feb.				17	10 38 9	10 10.7	12 58
11	19 10 29	−21 46.0	9 51	27	11 23 58	5 20.6	13 4
12	19 15 43	21 40.0	9 53	28	11 28 29	4 50.6	13 5
13	19 20 58	21 33.4	9 54	29	11 33 0	4 20.4	13 5
June				Oct.			
14	5 10 7	+22 51.9	11 42	15	15 9 27	−18 9.1	13 37
15	5 15 25	23 0.3	11 44	16	15 14 23	18 31.5	13 38
16	5 20 44	23 8.0	11 45	17	15 19 20	18 53.4	13 39

Hor. Parallax: Jan. 1, 0′.15; Feb. 1, 0′.12; July 1, 0′.08; Aug. 1, 0′.09; Sept. 1, 0′.09; Oct. 1, 0′.10.

Semi-Diameter: Jan. 1, 0′.14; Feb. 1, 0′.12; July 1, 0′.08; Aug. 1, 0′.08; Sept. 1, 0′.09; Oct. 1, 0′.09.

MARS, 1936

GREENWICH CIVIL TIME

(Pages 142-145, N. A.)

Date	Apparent Right Ascension 0h	Apparent Declination 0h	Transit, Meridian of Greenwich	Date	Apparent Right Ascension 0h	Apparent Declination 0h	Transit, Meridian of Greenwich
Jan.	h m s	° ′	h m	Oct.	h m s	° ′	h m
30	22 55 7	− 7 50.0	14 22	17	10 58 2	+ 8 3.9	9 16
31	22 58 0	7 31.5	14 21	18	11 0 20	7 50.0	9 14
Feb.				19	11 2 37	7 36.0	9 13
1	23 0 53	− 7 13.0	14 20	Nov.			
10	23 26 37	4 24.0	14 10	26	12 27 9	− 1 19.7	8 8
11	23 29 28	4 5.0	14 9	27	12 29 19	1 33.5	8 6
12	23 32 18	3 46.1	14 8	28	12 31 29	1 47.3	8 4
May				Dec.			
5	3 26 28	+19 0.5	12 35	7	12 50 54	− 3 49.6	7 48
6	3 29 23	19 11.5	12 34	8	12 53 2	4 3.0	7 46
7	3 32 18	19 22.4	12 33	9	12 55 11	4 16.3	7 44

Hor. Parallax: Jan. 1, 0′.07; Feb. 1, 0′.07; May 1, 0′.06; Oct. 1, 0′.06; Nov. 1, 0′.07; Dec. 1, 0′.08; Dec. 32, 0′.09.

Semi-Diameter: Jan. 1, 0′.04; Feb. 1, 0′.04; May 1, 0′.03; Oct. 1, 0′.03; Nov. 1, 0′.04; Dec. 1, 0′.04; Dec. 32, 0′.05.

JUPITER, 1936

GREENWICH CIVIL TIME

(Pages 146-149, N. A.)

Date	Apparent Right Ascension	Apparent Declination	Transit, Meridian of Greenwich	Date	Apparent Right Ascension	Apparent Declination	Transit, Meridian of Greenwich
	0h	0h			0h	0h	
Jan.	h m s	° ′	h m	Dec.	h m s	° ′	h m
13	16 51 23	−21 53.8	9 25	24	18 21 25	−23 16.3	12 11
14	16 52 14	21 55.2	9 22	25	18 22 25	23 15.9	12 8
15	16 53 5	21 56.6	9 19	26	18 23 25	23 15.4	12 5
July							
3	17 3 9	−22 17.8	22 16				
4	17 2 41	22 17.4	22 11				
5	17 2 14	22 16.9	22 7				

Hor. Parallax: Jan. 1, 0′.02; Feb. 1, 0′.02; July 1, 0′.03; Dec. 1, 0′.02; Dec. 32, 0′.02.

Semi-Diameter: Jan. 1, 0′.25; Feb. 1, 0′.26; July 1, 0′.35; Dec. 1, 0′.25; Dec. 32, 0′.25.

SATURN, 1936

GREENWICH CIVIL TIME

(Pages 150-153, N. A.)

Date	Apparent Right Ascension	Apparent Declination	Transit, Meridian of Greenwich	Date	Apparent Right Ascension	Apparent Declination	Transit, Meridian of Greenwich
	0h	0h			0h	0h	
May	h m s	° ′	h m	Oct.	h m s	° ′	h m
5	23 25 11	− 5 46.0	8 33	4	23 17 39	− 7 3.5	22 24
6	23 25 31	5 44.1	8 30	5	23 17 24	7 5.0	22 20
7	23 25 50	5 42.3	8 26	6	23 17 9	7 6.5	22 15
June				Dec.			
14	23 34 33	− 4 55.9	6 5	25	23 15 3	− 7 6.3	16 59
15	23 34 40	4 55.4	6 1	26	23 15 16	7 4.8	16 55
16	23 34 47	4 54.9	5 58	27	23 15 30	7 3.1	16 52
Sept.							
7	23 25 4	− 6 16.0	0 21				
8	23 24 47	6 17.9	0 17				
9	23 24 31	6 19.8	0 13				

Hor. Parallax: May 1, 0′.01; June 1, 0′.02; Sept. 1, 0′.02; Oct. 1, 0′.02; Dec. 1, 0′.02; Dec. 32, 0′.01.

Semi-Diameter: May 1, 0′.12; June 1, 0′.13; Sept. 1, 0′.14; Oct. 1, 0′.14; Dec. 1, 0′.13; Dec. 32, 0′.13.

ADDENDA

In order that the student may have examples of the latest methods used in solving problems, I am giving problems worked for the following:

1. The method of using the Greenwich Hour Angle for longitude observations of sun; star; planet and moon.
2. The Identification of Stars.
3. The Visibility and Distance of a Light or Object.

It is hoped that the addition of these problems will be of assistance in preparing for examination before the U. S. Local Inspectors.

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GREENWICH HOUR ANGLE METHOD

The method of using the Greenwich Hour Angle (G. H. A.) which has been embodied in The American Nautical Almanac since 1934 is coming more into use, and several examples taken at random from the various longitude problems are worked in full in this Addenda in order that the student may understand this newer method.

In the sun problems it eliminates the use of Apparent Time; in star, planet and moon observations the use of Right Ascension and Siderial Time, thereby shortening the work and interpolations to a great extent. The method will be found to be of greater advantage when used in star; planet and moon observations.

It is advisable, in my opinion, to practice working both methods and then choose between them. Both are equally correct.

LONGITUDE BY SUN

RULE:

1. Find Greenwich Civil Time (G. C. T.)
2. Find declination for G. C. T.
3. Find Polar Distance (Rule 3 Page 339).

4. Find true altitude (Rule 5 Page 340).
5. Find remainder (Rules 6 and 7 Page 340).
6. Find sum of logs. (Rule 8 Page 340).
7. Find Local Hour Angle as follows: Logarithm Haversine (Table 45) that agrees with sum of logs will be Local Hour Angle (L. H. A.) always taken from top of page and expressed in arc.
8. Find Greenwich Hour Angle (G. H. A.) as follows: Using Greenwich Civil Time (G. C. T.) look in Nautical Almanac (Pages 4-39 inc.) take out Sun's G. H. A. for even hour and add correction to G. H. A. for hours, minutes and seconds of Greenwich time past even hour from table found in Almanac at end of each month.
9. Under L. H. A. put down G. H. A. and the two plus or minus according to the rule below will give longitude in arc.
10. To G. H. A. (which is always given west) apply the L. H. A., adding if east, subtracting if west. If the L. H. A. is west and greater than the G. H. A. the longitude is east. In all other cases the longitude is west. If the longitude is more than 180° W. and less than 360° W., substract it from 360° and call it longitude east. If the longitude is more than 360° W., subtract 360° from it and call it longitude west.

PROBLEM NO. 1

(Page 342)

January 31, 1936. A.M. at ship. Obs. Alt. Sun's L. L. 13° 54′. Dip 36 ft. Chron. read 2h 46m 17s P.M., which was fast 34m 34s. Lat. 25° 44′ N. Required Long.?

Chron.	14h 46m 17s		Decl. 31d 14h	17° 36′ .1
fast	— 34m 34s		Corr. for .2h	— .1
G. C. T. 31d	14h 11m 43s		Decl. 31d 14.2h	17° 36′ .0 S
				90° 0′ .0
			Pol. Dist.	107° 36′ .0

Obs. Alt.		13° 54′ 0″		
S. D.	+	16′ 16″		
		14° 10′ 16″		
Dip	−	5′ 53″		
		14° 4′ 23″		
R. & P.	−	3′ 40″		
True Alt. (h)		14° 0′ 43″		
Lat.		25° 44′ 0″	Sec.	.04536
P. D.		107° 36′ 0″	Csc	.02082
		2)147° 20′ 43″		
Half Sum (s)		73° 40′ 21″	Cos	9.44890
h		14° 0′ 43″		
Rem. (s-h)		59° 39′ 38″	Sin	9.93604
			Log. Hav.	9.45112

L.H.A. (Tabl 45)	64° 13′ .3 E	G. H. A. (N. A.) 31d 14h	26° 37′ .8
G. H. A. (N. A.)	29° 33′ .6 W	Corr. for 11m	2° 45′ .0
		Corr. for 43s	10′ .8
		G. H. A. 14h 11m 43s	29° 33′ .6
Long. (Rule 10)	93° 46′ 54″ W		

PROBLEM NO. 3

(Page 344)

March 11, 1936. A.M. at ship. Obs. Alt. Sun's L. L. 28° 13′. Dip 38 ft. Chron. read 3h 12m 15s A.M. (Chron. correct) Lat. 31° 46′ S. Req. Long.?

G. C. T. 11d	3h 12m 15s			Decl. 11d 2h	3° 49′ .8
				Corr. for 1.2 h	− 1′ .2
Obs. At		28° 13′ 0″			
S. D.	+	16′ 8″		Decl. 11d 3.2h	3° 48′ .6 S
					−90° 0′ .0
		28° 29′ 8″			
Dip	−	6′ 2″		P. D.	86° 11′ .4
		28° 23′ 6″			
R. & P.	−	1′ 40″			
h		28° 21′ 26″			
Lat.		31° 46′ 0″	Sec	.07048	
P. D.		86° 11′ 24″	Csc	.00096	
		2)146° 18′ 50″			

s	73° 9′ 25″	Cos	9.46202
h	28° 21′ 26″		
s−h	44° 47′ 59″	Sin	9.84796
		Log. Hav.	9.38142

L. H. A.	58° 45′ .5 E		
G. H. A.	225° 29′ .9 W	G. H. A. 11d 2h	207° 26′ .1
	284° 15′ .4	Corr. for 1h 12m	18° 0′ .0
	360° 0′ .0	Corr. for 15s	3′ .8
Long.	75° 44′ 36″ E	G. H. A. 3h 12m 15s	225° 29′ .9

LONGITUDE BY FIXED STAR

RULE:

1. Find G. C. T.
2. Find Declination.
3. Find Polar Distance.
4. Find True Altitude (Rule 6 Page 430).
5. Find Remainder (Rule 7 Page 430).
6. Find sum of logs (Rule 8 Page 430).
7. Log. Haversine (Table 45) that agrees with sum of logs will be Local Hour Angle (L. H. A.) in arc.
8. Find Greenwich Hour Angle (G. H. A.) from Nautical Almanac Pages 162-209 of 1936 almanac using G. C. T. and date, and correct same by table in Nautical Almanac pages 210-212 (Correction to be added to Tabulated Greenwich Hour Angle of Stars).
9. Under L. H. A. put down G. H. A. and the two plus or minus according to the rule below will give longitude in arc.
10. To G. H. A. apply the L. H. A., adding if east, subtracting if west. If the L. H. A. is west and greater than the G. H. A. the longitude is east. In all other cases the longitude is west. If the longitude is more than 180° W. and less than 360° W., subtract it from 360° and call it longitude east. If the longitude is more than 360° W., subtract 360° from it and call it longitude west.

PROBLEM NO. 1

(Page 431)

Jan. 31, 1936. A. M. at ship. Obs. Alt. *Spica 45° 50′ bearing W. Dip 36 ft. Chron. read 1h 14m 35s P. M., which was fast on Jan. 11d 31m 34s and gaining 9s daily. Lat. 25° 53′ N. D. R. Long. 94° W. Required longitude?

Chrom.	13h 14m 35s	Interval 20.5 days	
fast	− 31m 34s	D. R. 9s × 20.5 = 184s	
		Acc. rate 3m 4s gaining	
	12h 43m 1s		
Acc. rate	− 3m 4s		
G. C. T. 31d	12h 39m 57s	Decl.	10° 49′ .8 S
			+90° 0′ .0
		P. D.	100° 49′ .8
Obs. Alt.	45° 50′ 0″		
Corr. (46)	− 6′ 50″		
h	45° 43′ 10″		
Lat.	25° 53′ 0″	Sec.	.04591
P. D.	100° 49′ 48″	Csc	.00781
	2)172° 25′ 58″		
s	86° 12′ 59″	Cos	8.81947
s − h	40° 29′ 49″	Sin	9.81252
		Log. Hav.	8.68571

L. H. A. (Table 45)	25° 26′.6 W	G. H. A. 31d 0h G. C. T.	288° 35′.2
G. H. A. (N. A.)	479° 5′.7 W	Corr. for 12h 39m	190° 16′.2
	453° 39′.1 W	Corr. for 57s	14′.3
	360° 0′.0	G. H. A. 12h 39m 57s	479° 5′.7
Long.	93° 39′ 6″ W		

PROBLEM NO. 3

(Page 433)

June 12, 1936. P. M. at ship. Obs. Alt. *Regulus 26° 18′ 32″ bearing W. Dip 17 ft. Chron. read 2h 2m 12s P. M., fast 14m 8s. Lat. 37° 18′ N. Long. by D. R. 110° E. Required longitude?

Chron.	14h 2m 12s		Decl.	12° 16′.7 N
fast	− 14m 8s			−90° 0′.0
G. C. T. 12d	13h 48m 4s		P. D.	77° 43′.3
Obs. Alt.	26° 18′ 32″			
Corr. (46)	− 6′ 0″			
h	26° 12′ 32″			
Lat.	37° 18′ 0″	Sec.	.09937	
P. D.	77° 43′ 18″	Csc	.01005	
	2)141° 13′ 50″			
s	70° 36′ 55″	Cos	9.52102	
s−h	44° 24′ 23″	Sin	9.84494	
		Log. Hav.	9.47538	

L. H. A. (Table 45)	66° 16′.3 W	G. H. A. 12d 0h	G. C. T. 108° 53′.4
G. H. A. (N. A.)	316° 28′.4 W	Corr. for 13h 48m	207° 34′.0
	250° 12′.1	Corr. for 4s	1′.0
	360° 0′.0	G. H. A. 13h 48m 4s	316° 28′.4
Long.	109° 47′ 54″ E		

LONGITUDE BY PLANET

RULE:

1. Find G. C. T. and date.
2. Find Declination (Rule 3 Page 441).
3. Find Polar Distance.
4. True Altitude (Rule 6 Page 441).
5. Remainder (Rule 7 Page 441).
6. Find sum of logs (Rule 8 Page 441).
7. Find Local Hour Angle in arc as follows: Log. Haversine (Table 45) that agrees with sum of logs will be L. H. A. in arc.

8. Find Greenwich Hour Angle as follows:
   (a) Take out G. H. A. for Greenwich date under Oh G. C. T. and variation per minute to nearest hundredth of minute (Pages 138-153 in 1936 N. A.)
   (b) Under G. H. A. put down correction for hours and half hours of G. C. T. from page 158 of 1936 N. A. found in column of the Variation of Hour Angle per Minute.
   (c) Under above put down correction for minutes past the hour or half hour of G. C. T. from page 159 of 1936 N. A. found in same column as above.
   (d) Under above put down correction for seconds from page 159 of 1936 N. A.
   (e) Add these together and the result will be G. H. A. in arc always West.
9. Under L. H. A. put down G. H. A. and the two plus or minus according to the rule below will give longitude in arc.
10. To G. H. A. apply the L. H. A., adding if east, subtracting if west. If the L. H. A. is west and greater than the G. H. A. the longitude is east. In all other cases the longitude is west. If the longitude is more than 180° W. and less than 360° W., subtract it from 360° and call it longitude east. If the longitude is more than 360° W., subtract 360° from it and call it longitude west.

PROBLEM NO. 1

(Page 442)

Jan. 31, 1936. A. M. at ship. Obs. Alt. Planet "Mars" 18° 55′ bearing E. Dip 36 ft. Chron. read 11h 11m 13s A. M., which was fast 34m 34s. Lat. 25° 53′ N. Long. by D. R. 9° W. Required longitude?

Chron.	11h 11m 13s	Decl. 31d 0h	7° 31′.5
fast	− 34m 34s	Corr. for 10h 37m	− 8′.2
G. C. T. 31d	10h 36m 39s	Dec. 31d 10h 37m	7° 23′.3 S
			+90° 0′.0
		Pol. Dist.	97° 23′.3

Obs. Alt.	18° 55′ 0″		
H. P. & S. D.	+ 6″		
	18° 55′ 6″		
Corr. (46)	− 8′ 42″		
h	18° 46′ 24″		
Lat.	25° 53′ 0″	Sec.	.04591
P. D.	97° 23′ 18″	Csc	.00362
	2)142° 2′ 42″		
s	71° 1′ 21″	Cos	9.51214
s − h	52° 14′ 57″	Sin	9.89800
		Log. Hav.	9.45967

L. H. A.	64° 56′.2 E	Variation of G. H. A. per Min.	15′.01
G. H. A.	303° 49′.2 W		
	368° 45′.4	G. H. A. 31d 0h	144° 33′.0
	−360° 0′.0	Corr. for 10h 30m	157° 36′.3
Long.	8° 45′ 24″ W	Corr. for 6m	1° 30′.1
		Corr. for 39s	9′.8
		G. H. A. 31d 10h 36m 39s	303° 49′.2 W

PROBLEM NO. 6

(Page 447)

Aug. 16, 1936. A. M. at ship. Obs. Alt. Planet "Venus" 24° 38′ 50″ bearing E. I. E. +4′ 30″. Dip 29 ft. Chron. read 5h 28m 32s A. M., which was slow on May 9, 14 m 39s and gaining 3s .7 daily. Lat. 36° 56′ S. Long. by D. R. 62° 15′ E. Required longitude?

Chron.	5h 28m 32s	Interval 99.2 days	
slow	+ 14m 39s	D. R. 3s .7 × 99.2 = 367s	
	5h 43m 11s	Acc. rate gaining 6m 7s	
Acc. rate	− 6m 7s		
G. C. T. 16d	5h 37m 4s	Decl. 16d 0h	10° 38′.4
		Corr. for 5h 37m	− 6′.5
Obs. Alt.	24° 38′ 50″	Dec. 16d 5h 37m	10° 31′.9 N
I. E.	+ 4′ 30″		+ 90° 0′.0
	24° 43′ 20″	Pol. Dist.	100° 31′.9

H. P. & S. D.	+ 10″		
	24° 43′ 30″		
Corr. (46)	− 7′ 23″		
h	24° 36′ 7″		
Lat.	36° 56′ 0″	Sec.	.09727
P. D.	100° 31′ 54″	Csc	.00738
	2)162° 4′ 1″		
s	81° 2′ 0″	Cos	9.19273
s − h	56° 25′ 53″	Sin	9.92076
		Log. Hav.	9.21814

L. H. A.	47° 58′.3 E	Variation per Min. 14′.9926	
G. H. A.	250° 2′.5 W		
	298° 0′.8	G. H. A. 16d 0h	165° 49′.9
	360° 0′.0	Corr. for 5h 30m	82° 26′.7
Long.	61° 59′ 12″ E	Corr. for 7m	1° 44′.9
		Corr. for 4s	1′.0
		G. H. A. 16d 5h 37m 4s	250° 2′.5 W

LONGITUDE BY MOON

RULE:

1. Find G.C.T.
2. Find Declination (Rules 2 and 3 Page 448).
3. Find Polar Distance.
4. Find True Altitude (Rule 5 Page 448).
5. Find Remainder (Rule 6 Page 448).
6. Find sum of logs (Rule 7 Page 448).
7. Log. Haversine (Table 45) that agrees with sum of logs will be L. H. A. in arc.
8. Find G. H. A. as follows:
   (a) Take out G. H. A. from Almanac for Greenwich date and hour of Greenwich time.
   (b) Find Variation of Hour Angle per hour between that hour and next following hour by subtracting.

(c) Under G. H. A. put down correction for minutes past the hour of G. C. T. found on Page 132 of 1936 Nautical Almanac and in the column of Variation of Hour Angle per Hour.

(d) Under above put down correction for seconds Page 132 (N. A.)

(e) Add these together and the result will be G. H. A. in arc always West.

9. Under L. H. A. put down G. H. A. and the two plus or minus according to the rule below will give longitude in arc.

10. To G. H. A. apply the L. H. A., adding if east, subtracting if west. If the L. H. A. is west and greater than the G. H. A. the longitude is east. In all other cases the longitude is west. If the longitude is more than 180° W. and less than 360° W., subtract it from 360° and call it longitude east. If the longitude is more than 360° W., subtract 360° from it and call it longitude west.

PROBLEM NO. 1

(Page 449)

May 17, 1936. P. M. at ship. Obs. Alt. Moon's L. L. 21° 41′ 18″ bearing West. I. E. +3° 40″. Dip 15 ft. Chron. read 10h 43m 18s P. M., which was slow on April 12, 3m 29s and losing 4s.2 daily. Lat. 32° 46′ N. Long. by D. R. 134° W. Required Long.?

Chron.	22h 43m 18s	Interval 35.9 days	
slow	+ 3m 29s	D. R. 4s.2×35.9=151s	
		Acc. rate 2m 31s losing.	
	22h 46m 47s		
Acc. rate	+ 2m 31s		
G. C. T. 17d	22h 49m 18s	Decl. 17d 22h	10° 54′.2
		Corr. for 49m	+ 11′.2
Obs. Alt.	21° 41′ 18″	Decl. 17d 22h 49m	11° 5′.4 N
I. E.	+ 3′ 40″		−90° 0′.0
	21° 44′ 58″	Pol. Dist.	78° 54′.6
Corr. (49)	+ 1° 6′ 27″		
h	22° 51′ 25″	H. P. 60′.4	
Lat.	32° 46′ 0″	Sec. .07527	
P. D.	78° 54′ 36″	Csc .00818	
	2)134° 32′ 1″		
s	67° 16′ 0″	Cos 9.58709	
s−h	44° 24′ 35″	Sin 9.84497	
		Log. Hav. 9.51551	
L. H. A.	69° 50′.8 W	Var. of H. A. per hour 14° 27′.4	
G. H. A.	204° 41′.4 W		
Long.	134° 50′ 36″ W	G. H. A. 17d 22h	192° 48′.7
		Corr. for 49m	11° 48′.4
		Corr. for 18s	4′.3
		G. H. A. 22h 49m 18s	204° 41′.4

PROBLEM NO. 2

(Page 450)

Dec. 10, 1936. A. M. at ship. Obs. Alt. Moon's U. L. 31° 8′ 30″ bearing East. I. E. −2′ 15″. Dip 21 ft. Chron. read Dec. 9, 9h 12m 37s P. M., which was fast on Sept. 12, 7m 49s and losing 3s.8 daily. Lat. 23° 39′ S. Long. by D. R. 111° E. Required longitude?

Chron.	21h 12m 37s	Interval 88.9 days	
fast	− 7m 49s	D. R. 3s.8 × 88.9 = 338s	
	21h 4m 48s	Acc. rate 5m 38s losing	
Acc. rate	+ 5m 38s		
G. C. T. 9d	21h 10m 26s	Decl. 9d 21h	16° 18′.8
		Corr. for 10m	+ 1′.5
		Decl. 9d 21h 10m	16° 20′.3 S
			−90° 0′.0
Obs. Alt.	31° 8′ 30″	Pol. Dist.	73° 39′.7
I. E.	− 2′ 15″		
	31° 6′ 15″	H. P. 54′.0	
Corr. (49)	+ 25′ 27″		
h	31° 31′ 42″		
Lat.	23° 39′ 0″	Sec. .03810	
P. D.	73° 39′ 42″	Csc .01790	
	2)128° 50′ 24″		
s	64° 25′ 12″	Cos 9.63526	
s − h	32° 53′ 30″	Sin 9.73484	
		Log. Hav. 9.42610	
L. H. A.	62° 11′.5 E	Var. of H. A. per hour 14° 33′.0	
G. H. A.	186° 54′.4W		
	249° 5′.9	G. H. A. 9d 21h	184° 22′.6
	360° 0′.0	Corr. for 10m	2° 25′.5
		Corr. for 26s	6′.3
Long.	110° 54′ 6″ E	G. H. A. 9d 21h 10m 26s	186° 54′.4 W

IDENTIFICATION OF STARS

The following problems are worked by using Star Identification Table H. O. 127. The explanation given in the table is very simple and by practicing the problem contained therein and the below problems the student should have no trouble with this method.

PROBLEM NO. 1

May 9, 1936. About 5.20 A. M. at ship. D. R. position 32° 19′ N. 126° 10′ W. the altitude of an unknown star was observed 19° 59′ 30″ bearing N 148° E (true). Chron. read 1h 44m 25s. Required name of star?

G. C. T. 9d	13h 44m 25s	Lat. 32° N.	To enter H. O. 127
S. T. 0h G. C. T.	15h 6m 31s	Az. 148°	
Corr.	2m 15s	Alt. 20°	
G. S. T.	28h 53m 11s		
Long.	8h 24m 40s	Decl. −29.6 S	From H. O. 127
		H. A. 2h 20m	
L. S. T.	20h 28m 31s		
H. A. East	+ 2h 20m 0s		
*R. A.	22h 48m 31s		

Note: If H. A. is East it is + to L. S. T.
If H. A. is West it is − to L. S. T.

Comparing * R. A. and Decl. on Pages 160-161 (N. A.) it is found that the star is "Fomalhaut."

PROBLEM NO. 2

June 12, 1936. P. M. at ship. D. R. position 37° 18′ N. 110° E. The altitude of an unknown star was 26° 18′ 30″ bearing N 95° W. Chron. read 2h 2m 12s P. M. which was fast 14m 8s. Required name of star?

Chron.	14h 2m 12s	Enter H. O. 127 with:
fast	− 14m 8s	Lat. 38° N
		Az. 96°
G. C. T. 12d	13h 48m 4s	Alt. 26°
S. T. 0h G. C. T.	17h 20m 33s	
Corr.	2m 16s	
G. S. T.	31h 10m 54s	From H. O. 127 is found:
Long.	+ 7h 20m 0s	Decl. 11.3° N
	38h 30m 54s	H. A. 4h 22m West
	−24h 0m 0s	
L. S. T.	14h 30m 54s	
H. A. (west)	− 4h 22m 0s	
*R. A.	10h 8m 54s	

Comparing *R. A. and Decl. on Pages 160-161 (N. A.) it is found that the star is "Regulus".

PROBLEM NO. 3

Jan. 31, 1936, A. M. at ship. D. R. position 25° 53′ N. 94° W. Altitude of unknown star 45° 50′ bearing N 143° W. Chron. read 1h 14m 35s P. M. which was fast 34m 38s. Required name of star?

Chron.	13h 14m 35s	Enter H. O. 127 with:
fast	− 34m 38s	Lat. 26°
		Az. 144°
G. C. T. 31d	12h 39m 57s	Alt. 46°
S. T. 0h G. C. T.	8h 36m 12s	
Corr.	2m 5s	
G. S. T.	21h 18m 14s	From H. O. 127 is found:
Long.	− 6h 16m 0s	Decl. 10.9° S
		H. A. 1h 39m West
L. S. T.	15h 2m 14s	
H. A. (west)	− 1h 39m 0s	
*R. A.	13h 23m 14s	

Comparing *R. A. and Decl. in N. A. it is found that the star is "Spica".

PROBLEM NO. 4

March 20, 1936. P. M. at ship. D. R. position 32° 17′ N. 165° W. Altitude of unknown star 32° 17′ 30″ bearing N 103° E. Chron. read March 21d 1h 16m 23s which was fast 3m 46s. Required name of star?

Chron.	1h 16m 23s	Enter H. O. 127 with:
fast	− 3m 46s	Lat. 32°
		Az. 104°
G. C. T. 21d	1h 12m 37s	Alt. 32°
S. T. 0h G. C. T.	11h 53m 19s	
Corr.	12s	
G. S. T.	13h 6m 8s	From H. O. 127 is found:
Long.	−11h 0m 0s	Decl. 6.1° N
		H. A. 3h 43m East
L. S. T.	2h 6m 8s	
H. A. (east)	+ 3h 43m 0s	
*R. A.	5h 49m 8s	

The star is "Betelgeux".

PROBLEM NO. 5

Oct. 28, 1936. A. M. at ship. D. R. position 14° 23′ S. 1° W. Altitude of unknown star 28° 50′ bearing S 104° W. Chron. read 9h 12m 28s A. M. which was fast 4m 10s. Required name of star?

Chron.	9h 12m 28s	Enter H. O. 127 with:
fast	− 4m 10s	Lat. 14°
		Az. 104°
G. C. T. 28d	9h 8m 18s	Alt. 29°
S. T. 0h G. C. T.	2h 24m 38s	
Corr.	1m 30s	
G. S. T.	11h 34m 26s	From H. O. 127 is found:
Long.	− 4m 0s	Decl. 5° N.
		H. A. 3h 53m West
L. S. T.	11h 30m 26s	
H. A. (west)	− 3h 53m 0s	
*R. A.	7h 37m 26s	

The star is "Procyon".

PROBLEM NO. 6

Feb. 16, 1936. P. M. at ship. D. R. position 16° 46′ N. 7° 45′ E. Altitude of unknown star 24° 18′ bearing N 107° W. Chron. read 11h 16m 28s P. M. which was fast 15m 58s. Required name of star?

Chron.	23h 16m 28s		Enter H. O. 127 with:
fast	− 15m 58s		Lat. 16°
			Az. 108°
G. C. T. 16d	23h 0m 30s		Alt. 24°
S. T. 0h G. C. T.	9h 39m 17s		
Corr.	3m 46s		
G. S. T.	32h 43m 33s		From H. O. 127 is found:
Long.	+ 31m 0s		Decl. 9.2° S
			H. A. 4h 7m
L. S. T.	33h 14m 33s		
H. A. (west)	− 4h 7m 0s		
*R. A.	5h 7m 33s		

The star is "Rigel".

VISIBILITY AND DISTANCE OF A LIGHT OR OBJECT

This problem is to find the distance of visibility of a light or object, also to find the course to be steered to pass a certain distance off the light or object.

RULE:

1. From Table 6 (Bowditch) take out figures under "Nautical Miles" of height in feet of light or object.
2. From same table take out figures for height of observer's eye.
3. Always add these two, and the result will be distance of visibility in nautical miles.
4. To find course to be steered to pass a certain distance off light or object. Enter Table 2 (Bowditch) with distance of visibility in distance column, and distance desired to pass off light or object in departure column. Where these two agree, the course at top of page will be the bearing on the bow necessary to bring the light or object to pass the required distance off.
5. The difference between the two bearings will be the amount necessary to alter the course to pass the light or object the required distance off.

PROBLEM NO. 1

EXAMPLE:

A vessel is steering N 70° W (true) and observes a light dipping on the horizon whose height is 90 feet bearing 2¾ points on the port bow. The height of observer's eye is 39 feet. What course must vessel steer to pass 7 miles off of light?

Height of light 90 feet (Table 6) = 10.9
Height of eye 39 feet (Table 6) = + 7.1

Distance of visibility 18.0 nautical miles.

Dist. of visibility 18 (Table 2 Dist. column) = 23° bearing to pass
Dist. desired to pass 7 (Table 2 Dep. column) = 7 miles off

Bearing of light on bow 2¾ points = 31°
Bearing to pass 7 miles off = 23°

Amount to change course 8°
Vessel's course N 70° W (true)
Amount to change course 8°

True course to steer N 78° W to pass light 7 miles off.

PROBLEM NO. 2

A vessel is steering S 18° W (true) and observes a dipping light bearing 3¼ points on starboard bow. Height of light 420 ft., height of eye 15 ft. It is wished to pass this light 17.5 miles off. What true course should be steered?

Height of light 420 feet (Table 6) = 23.5
Height of eye 15 feet (Table 6) = 4.4

Distance of visibility 27.9 knots

Distance of visibility 27.9 (Table 2) = 39° bearing to pass 17.5
Distance desired to pass 17.5 (Table 2) miles off

Bearing of light on bow 3¼ points = 37°
Bearing to pass 17.5 miles off = 39°

Amount to change course 2°

Vessel's course (true) S 18° W
Amount to change course 2°

True course to steer S 16° W

PROBLEM NO. 3

A vessel is steering West (true) and observes a dipping light bearing 2½ points on port bow. Height of light 280 feet. Height of eye 60 feet. What true course should be steered to pass this light 4 miles off?

Height of light 280 feet (Table 6) = 19.2
Height of eye 60 feet (Table 6) = 8.9

Distance of visibility 28.1 knots.

Distance of visibility 28.1 (Table 2) = 8° bearing to pass 4 miles
Distance desired to pass 4 (Table 2) off.

Bearing of light on bow 2½ points = 28°
Bearing to pass 4 miles off = 8°

Amount to change course 20°

Vessel's course West (true) 90°
Amount to change course 20°

True course to steer S 70° W

PROBLEM NO. 4

Vessel's Course N 24° E (true). Object on horizon 120 ft. in height. Bearing 3 points on starboard bow. Height of eye 30 ft. What true course should be steered to pass object 6.5 miles off?

Height of object 120 feet (Table 6) = 12.6
Height of eye 30 feet (Table 6) = 6.3

Distance of visibility 18.9

Distance of visibility 18.9 (Table 2) = 20° bearing to pass 6.5
Distance desired to pass 6.5 (Table 2) miles off.

Bearing of object on bow 3 points = 34°
Bearing to pass 6.5 miles off = 20°

Amount to change course 14°

Vessel's course (true) N 24° E
Amount to change course 14°

True course to steer N 38° E

PROBLEM NO. 5

A vessel is steering East (true). A light is observed dipping on horizon whose height is 360 feet. Height of eye 80 feet. Light bearing 40° on port bow. What true course should be steered to pass light 15 miles off?

Height of light 360 feet (Table 6) = 21.7
Height of eye 80 feet (Table 6) = 10.3

Distance of visibility 32.0 knots

Distance of visibility 32.0 (Table 2) = 28° bearing to pass 15 miles off.
Distance desired to pass 15 (Table 2)

Bearing of light on bow = 40°
Bearing to pass 15 miles = 28°

Amount to change course 12°

Vessel's true course = 90°
Amount to change course 12°

True course to steer S 78° E

PROBLEM NO. 6

A vessel is steering S 15° E (true). A dipping light is observed 1¾ points on starboard bow. Height of light 200 feet. Height of eye 40 feet. What true course should be steered to pass light 8 miles off?

Height of light 200 feet (Table 6) = 16.2
Height of eye 40 feet (Table 6) = 7.2

Distance of visibility 23.4

Distance of visibility 23.4 (Table 2) = 20° bearing to pass 8 miles off.
Distance desired to pass 8 (Table 2)

Bearing of light on bow 1¾ points = 20°

No change of course. True course S 15° E.

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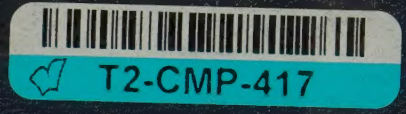
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